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[621 .337

Individual axle drive.

Mechanical systems used on electric locomotives and railcars, with an indication of the results obtained in service on railways of all kinds,

(Continued)*

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Chapter V.

DRIVING MECHANISMS BASED ON THE OLDHAM JOINT.

With regard to these mechanisms, there have been, so far as we know, no applications made or considered since 1933 other than the so-called « universal » mechanism, and its variations, of the Swiss SLM, Winterthur.

Fittings before 1933 were dealt with in Cde. indiv., pp. 60-67, figs. 126-139. Apart from isolated locomotives of the Swiss Federal Railways ([125]) and the Spanish Norte (now RENFE (RN) ([126]), there was only a series of 22 high speed locomotives (140 km./h. [87 m.p.h.]) type 2-AA-A1, of the G.I.P. (now Indian Government Railways, IGR) ([127]). These 22 locomotives, series EA/1, Nos. 4000, 4004-4024 (see fig. 213), worked fast trains on the electrified lines (1 500 V., direct current, 1 676 mm. [5′6$^{1}/_{32}$″] gauge) from Bombay Victoria to Kalyan, from which branch two important mountain lines, crossing the Ghaut mountains towards Poona and to Igatpuri, a total of about 200 km. (124 miles), electrified by the G.I.P. The behaviour of these locomotives is good and the driving

(*) See *Bulletin of the International Railway Congress Association*, Nos. of September, October and December 1947, pp. 823, 885 and 999 respectively, Nos. of February, April, July and October 1948, pp. 73, 227, 403 and 591 respectively.

([125]) See figs. 134, 135 and 138 of **Cde. indiv.**; also *Revue Polytechnique Suisse, SBZ*, 19/5/1932 (No. 12, Vol. 99), pp. 145-147, 11 figs.

([126]) See figs. 131-133 of **Cde. indiv.**

([127]) See figs. 126-130, 136, 137 and 139 of **Cde. indiv.** and bibliography thereto.

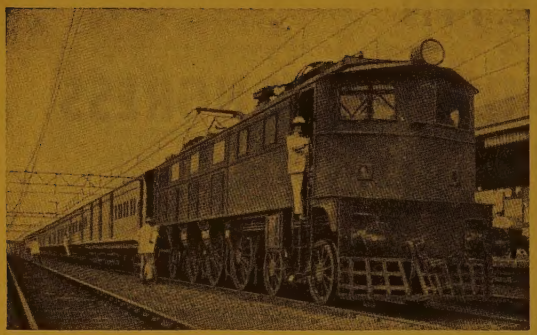


Fig. 213. — High speed, broad gauge, electric locomotive, type 2-AA-A1, series EA/1, Nos. 4004-4024, Great Indian Peninsula Railway (Indian Governement Railways), with passenger train at Kalyan Station.

mechanism has given satisfaction, and we shall not report further on them.

We now come to the uses made by the Swiss Federal Railways (single phase, 15 kV., $16\,^{2}/_{3}$ cycles).

In 1939, the Swiss Federal Railways put into service on the St. Gotthard line, a new super-locomotive, type 1A-A1A-A1 + 1A-A1A-A1, type Ae $^{8}/_{14}$, No. 11852 ([128]), which was faster and more powerful than the two preceding ones (No. 11801, with Brown Boveri-Buchli mechanism, see Chapter III — A, and fig. 70 of Cde. indiv.; No. 11851 with SLM « universal » mechanism — see figs. 134 and 135 of Cde. indiv.).

Cliché Oerlikon.

Fig. 214. — Electric twin locomotive, No. 11852, type 1A-A1A-A1+1A-A1A-A1, Ae $^{8}/_{14}$, Gotthard line Swiss Federal Railways, 12 000 H.P., 110 km./h. (68 m.p.h.).

([128]) See *CFF Bulletin*, Berne, May 1939, front cover and pp. 73-75, 2 figs. — *Bulletin Technique SLM*, Winterthur, Apl. 1941, pp. 3-8, 11 figs. — *Int. Ry. Congress Bulletin*, Oct. 1946, pp. 347 and 359. — *Bulletin Oerlikon*, Zurich, special number for Railway Congress, Lucerne, June 1947, pp. 4-5, 3 figs. (pp. 1752-1754 of same Bulletin No. 265, Jan./Feb. 1947).

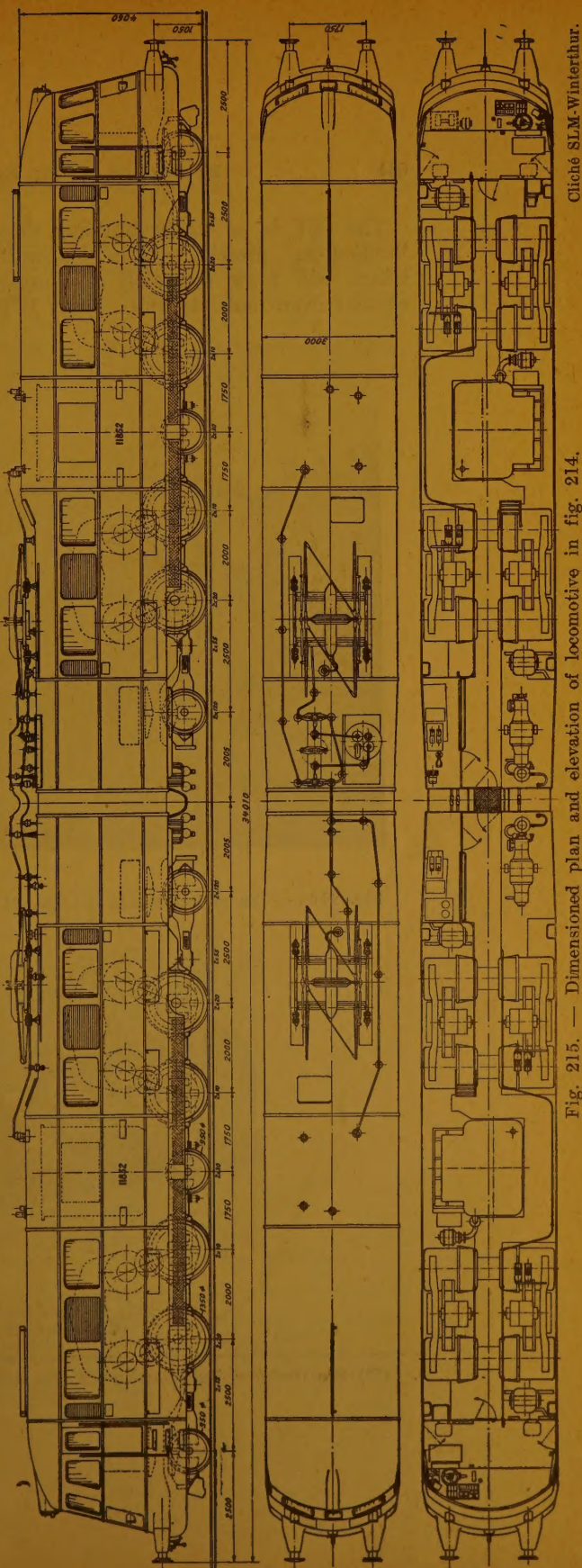
This locomotive is shown in figs. 214 to 216 and has the following characteristics :

Length over buffers	34 m. (111'6¾")
Total wheelbase . .	29 m. (95'1¾")
Wheelbase of each half-unit . . .	12.5 m. (41'3/16")
Hourly rating . .	12 100 H.P.
Corresponding tractive effort at 72 km./h. (45 m.p.h.)	44 000 kgr. (97 000 lbs.)
Max. speed in service	110 km./h. (68 m.p.h.)
Weight in working order	234 tons (230.303 Engl. t.)
Adhesive weight (129)	160/172 tons (157.47/169.283 Engl. t.)

There are 16 motors, 2 per axle, 2 remaining permanently connected in series. Electric braking is regenerative. It will be noted that with this locomotive the power has been increased by 43 % and the speed by 10 % by comparison with locomotive No. 11851, mentioned earlier.

Figs. 214 to 219 show, respectively, the locomotive with a train on the Gotthard North gradient; a dimensioned plan and elevation; the locomotive on a stabling road (opposite side to fig. 214); a combined carrying and driving axle; cross section through a driving axle and, finally, an axle with mechanism and geared half-rim, the near wheel having been removed. Figs. 217-219 complete figs. 136-138 of Cde. indiv.

(129) The normal adhesive weight of 160 t. (8×20) can be temporarily and artificially increased by a partial leverage arrangement on the central carrying axles of each half-locomotive, which increases the load on the two adjacent driving axles from 20 to 21.5 t. See publications noted in note (128).



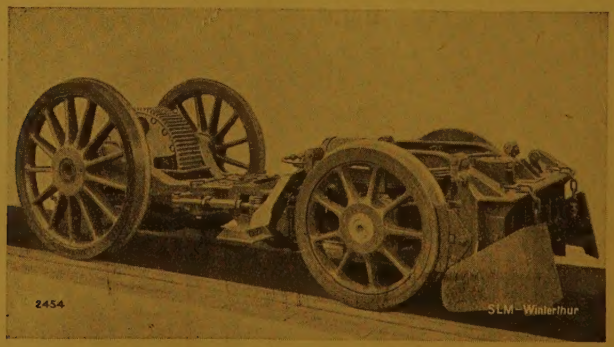
Cliché SLM-Winterthur.

Fig. 215. — Dimensioned plan and elevation of locomotive in fig. 214.

The CFF is no longer building these locomotives, preferring two half-units which will work separately and under control from multiple units (130). It is this factor which led this Administration to order successively from 1940 to 1943 — during the late war when traffic over the St Gotthard line was, for a variety

Cliché « Congrèsfer ».

Fig. 216. — Same locomotive as figs. 214-215, seen from opposite side, on a siding.



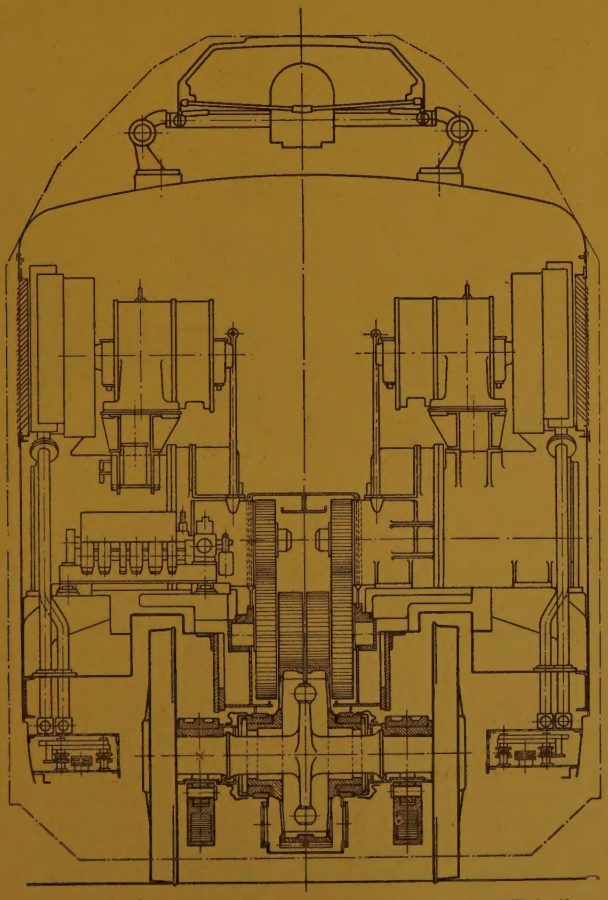
Cliché SLM-Winterthur.

Fig. 217. — Combined carrying-driving bogie of locomotive in figs. 214-216.

(130) See *Oerlikon Bulletin*, Zurich, No. 262, July/Aug., pp. 1729-1732, 5 figs., table.

of reasons, particularly intense — twelve 1A-AA-A1, Ae $^4/_5$, series 10801, locomotives, 2 of which, coupled together, could handle the same services as the super-locomotives.

These locomotives ([131]), of which the first 4, Nos. 10801 to 10804, were put into service in 1941, have the outer carrying wheels combined with a driving pair in one bogie in a similar manner to the super-locomotives. The middle carrying axle of the half-locomotives, Nos. 11801 and 11851/2, has been dispensed with.



Cliché SLM-Winterthur

Fig. 218. — Vertical section through driving axle, locomotive in figs. 214-217.

([131]) See *CFF Bulletin*, Berne, May 1941, pp. 78-80, F. STEINER, (in German), « Die Neuen Schnell- und Guterzuglokomotiven der Serie Ae $^4/_6$, No. 10801-10806 », 3 figs., table showing savings in weight by comparison with high speed locomotives ([128]). — *Bulletin Technique SLM*, Winterthur, Nov. 1941, pp. 25-26, 1 fig., and Oct. 1944, pp. 21-23, 6 figs. — *Bulletin Oerlikon*, Zurich, No. 265, Jan./Feb. 1947, pp. 1753-1754, 2 figs.

The main characteristics of these engines are :—

Length over buffers	17.26 m. (56′7½″)
Total wheelbase . .	12.20 m. (40′⅜″)
Diameter of driving wheels (4 axles) .	1 350 mm. (4′4⅞″)
Diameter of carrying wheels (2 axles) .	950 mm. (3′1⅜″)
Hourly rating (8 motors)	6 200 H.P.
Corresponding tractive effort (81 km./h. (50 m.p.h.)	20 000 kgr. (44 092 lbs.)
Max. speed in service	125 km./h. (78 m.p.h.)
Tare (adhesive weight)	106 (80) tons [104.32 (78.73) Engl. t.]

Figs. 220 to 224 show, respectively, a locomotive standing on a siding; a diagram of the wheel and motor arrangement; a set of wheels ready to receive the body; bogie; and a bogie frame; fig. 125 shows the layout of the bogies of the first six engines 10801 to 10806 and fig. 226 the improved bogies of the more recent 10807 to 10812; finally fig. 227 shows two of the locomotives coupled as a multiple unit.

As regards progress made with the bogies, the relevant publications ([132]) give details.

Before proceeding to special, or more recent, applications of the Winterthur

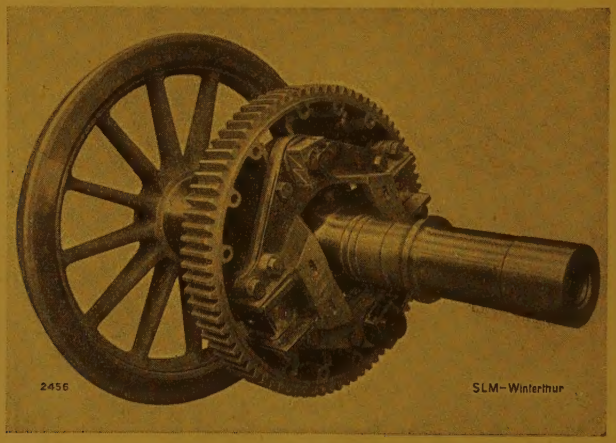


Fig. 219. — Driving mechanism with half-geared rim of locomotive in figs. 214-218 (see fig. 136 of **Cde. indiv.**).

« universal » mechanism, several peculiarities in its development may be noted.

During its early applications (on the GIP, as mentioned earlier) the axis of the intermediate gears, and also that of the two motors driving one axle, were set in the same vertical plane as the axis of the corresponding driving axle (see fig. 130 of **Cde. indiv.**, and description on pp. 64-66) whilst in subsequent applications (fig. 138 of **Cde. indiv.** and figs. 215-221 of this text) this common plane of the 3 superimposed axles has an angle of about 30° from the vertical.

([132]) See *Bulletin Technique SLM*, Winterthur, Oct. 1944, pp. 2-5. The bogie in fig 2 of this publication (see also figs. 222-226) is not a true « Java » type, the characteristic feature of the latter being that the pivot is *outside* the wheelbase. See right of fig. 16 and particularly figs. 46, 47, 128 and 129 of **Cde. indiv.**

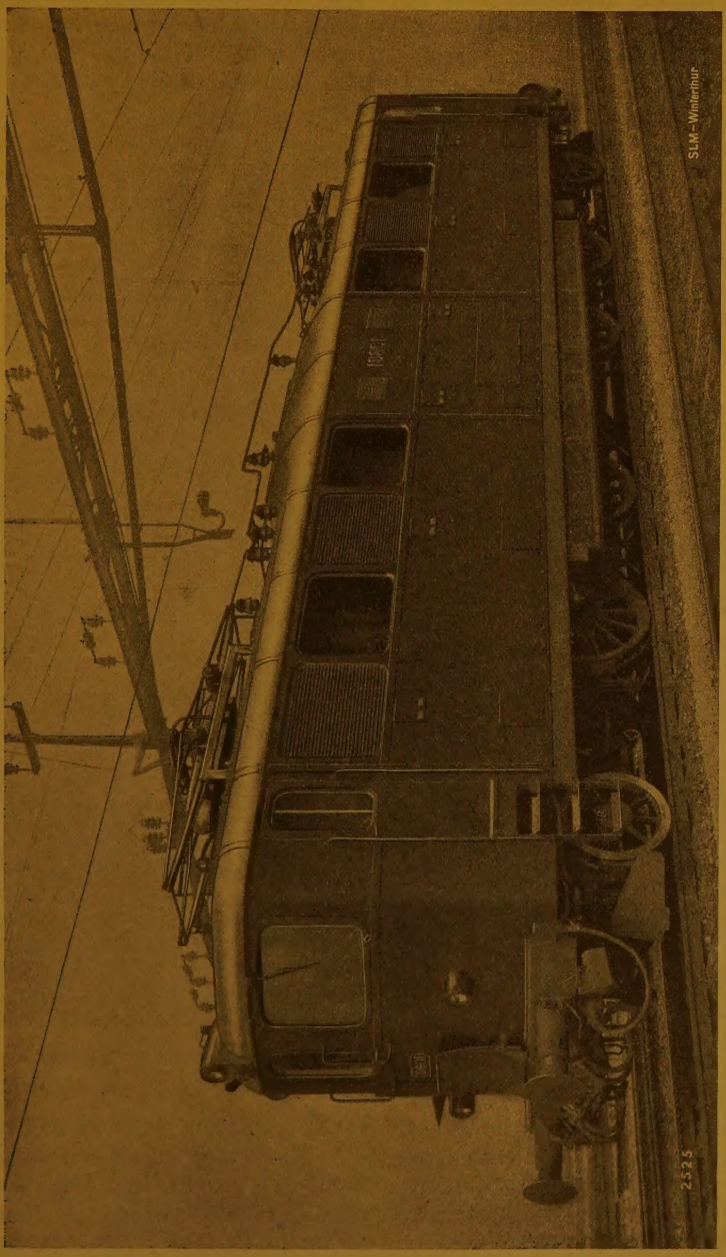


Fig. 220. — Locomotive for mountain line, Ae 4/6 series 10801, Swiss Federal Railways, SBB-CFF-SFF, St. Gotthard line.

The purpose of this arrangement is to move the motors from the centre of the locomotive, so as to leave sufficient room for the transformer in view of the single phase current used. Further, in recent applications, the main, and intermediate gear wheels, corresponding to a dummy intermediate shaft, are divided vertically into two parts, as can clearly be seen in figs. 218, 219 (half-geared rim) and 223.

We now pass to a special application of this same mechanism to a *steam locomotive* with individual axle drive. In 1936 the Nord Railway of France (now SNCF, « Région Nord ») ordered from SLM-Winterthur an experimental 60 atm. (1 000 lbs. per sq. inch.) high pressure steam locomotive, with individual motors (steam to DC) of 3 300 H.P. for maximum speeds of 130-140 km./h. (80-

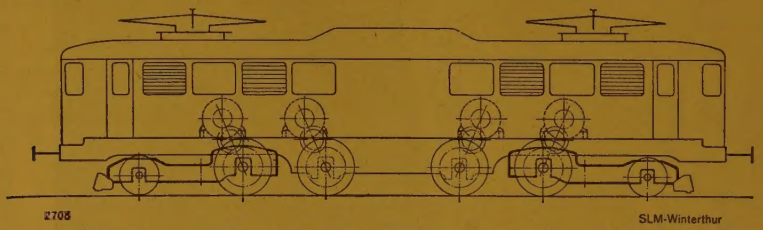


Fig. 221. — Diagram showing motor and wheel arrangement of locomotive in fig. 220.

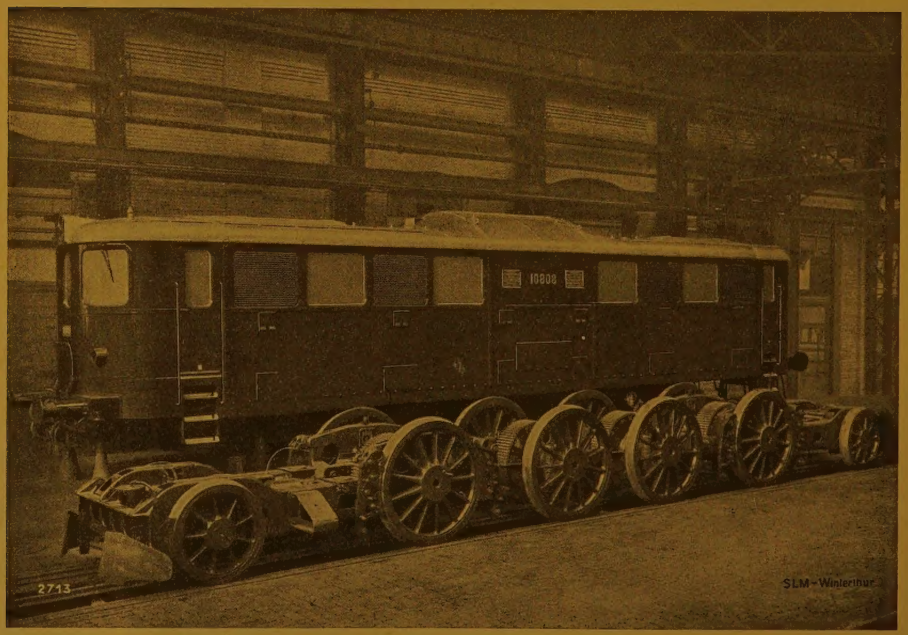


Fig. 222. — Set of wheels ready to receive the body, locomotives in figs. 220 and 221 (see figs. 219 and 235).

87 m.p.h.) (133). This was a 2-C_0-2 type engine, No. 232 P.1, which was put into service during 1943.

This is the third steam locomotive mentioned in this article; in that shown in figs. 94-97 the transmission mechanism from the turbine is to rod-coupled axles, but that in figs. 98 to 103 is for individual axle drive, as is the one now mentioned. It is not intended to describe this locomotive here and reference is made to the publications noted.

The mechanism for transmitting the drive from the motors of this locomotive is, moreover, very similar to that used in large electric locomotives; it transmits a drive in this case of more than 1 000 H.P. per driving axle.

Figs. 228 and 229 show the locomotive, SNCF, No. 232-P.1, with and without its streamlined cowling; fig. 230 is a part longitudinal section showing the motors and mechanism mounted over the driving axles; fig. 231 shows the mechanism mounted on the centre of a driving axle; fig. 232 a transverse section of the steam motor and driving mechanism; finally, fig. 233 shows the cast steel case for the transmission.

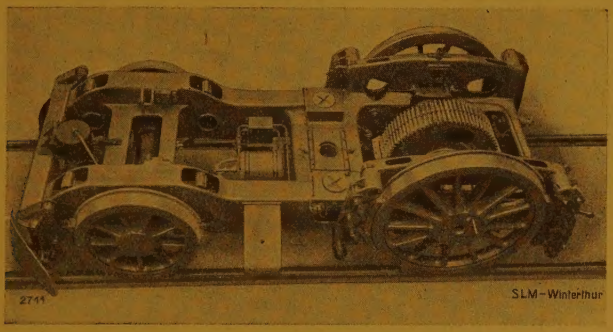
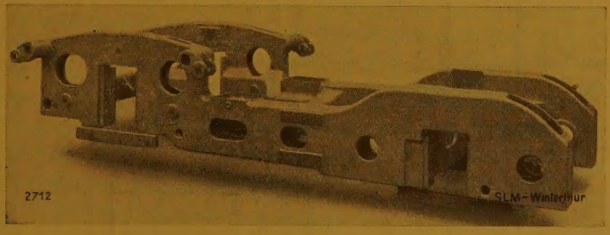


Fig. 223. — Combined bogie of locomotives in figs. 220-222 (see fig. 217).



Cliché SLM-Winterthur.

Fig. 224. — Cast steel frame of bogie in fig. 223.

(133) See *Revue Générale des Chemins de Fer*, Paris, Sept./Oct. 1943, « High pressure, individual motor, locomotive, type 232-P, SNCF », Chan, pp. 101-109, 11 figs., 4 tables, also same publication Mar./Apl. 1942. — *Revue Polytechnique Suisse SBZ*, Zurich, Vol. 128, Nos. 1 and 2, July 1946, « Einzelachs-Hochdruck-Lokomotive für die französische Staatsbahn », Nyffenegger, 21 figs. and diagrams, 1 table.

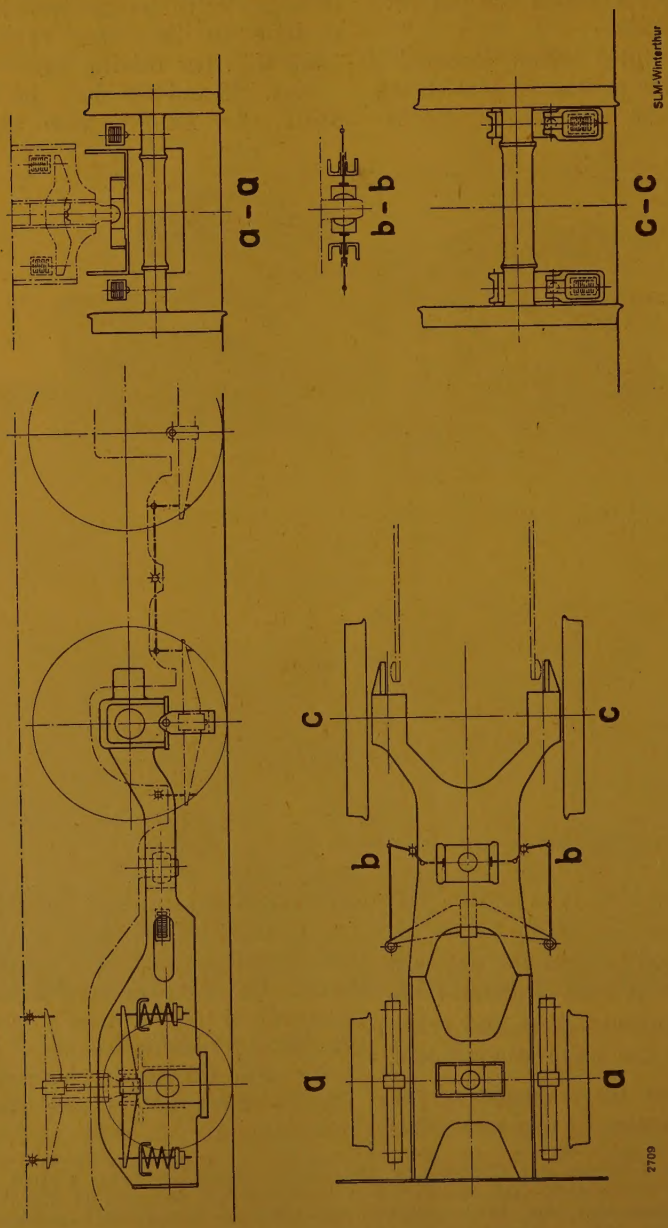


Fig. 225. — Diagram and sections showing arrangement of bogie in figs. 223-224, Ae 4/6 locomotives 10801-10806.

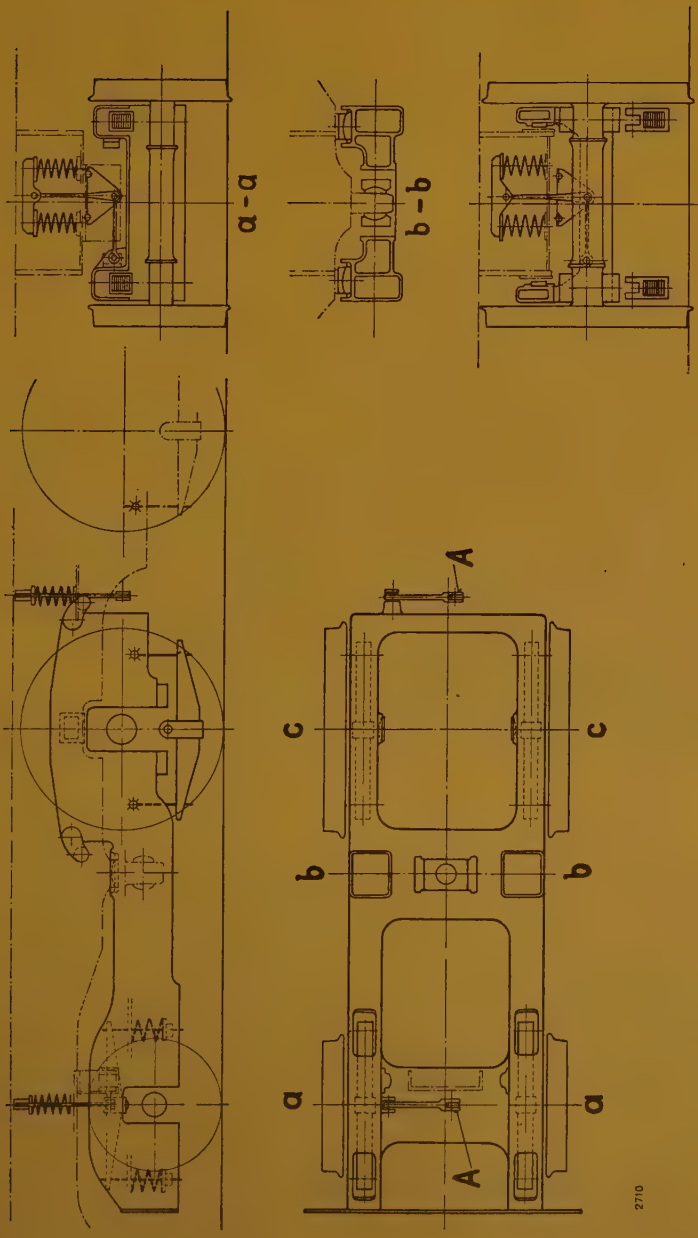


Fig. 226. — Same bogie as figs. 223-225 but with improved suspension.

Cliché SLM-Winterthur.

We come now to the most recent applications.

Early in 1946, the Dutch Railways, N.S. (Nederlandsche Spoorwegen) ordered from Oerlikon (MFO) and SLM (Winterthur) 10 powerful, high-speed electric locomotives (up to 160 km./h. [100 m. p.h.]), Nos. 1001-1010, the first of which

Cliché Oerlikon.

Fig. 227. — Two locomotives of figs. 220-222 coupled together with multi-unit control.

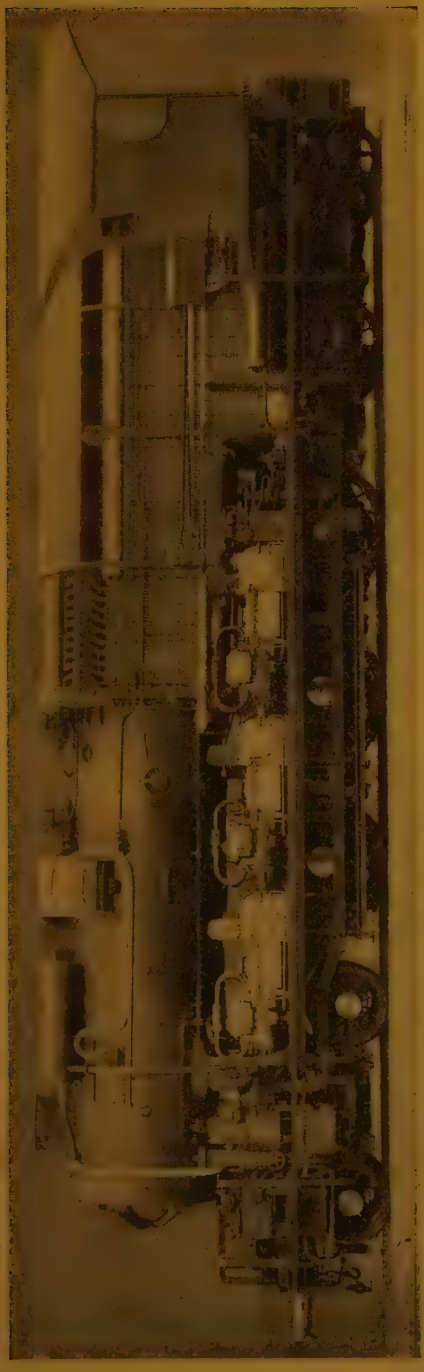
was completed in 1948 to take up its service as the first electric locomotive in the Low Countries ([134]). The first three locomotives were in service by June 1948.

Fig. 234 is a dimensioned sketch of the locomotives; they are 1A-AA-A1 type, fairly similar, as a whole, to the 10801, Ae $^{4}/_{6}$, Swiss Federal series described earlier, except that they are for direct current, 1 500 V., and the 8 motors (2 per axle) and those of the intermediate gears on the dummy axle are, as originally arranged, in the same *vertical* plane as the driving axle.

The general principle of the driving mechanism is therefore that already described (SLM-universal) but the mechanism itself, mounted in the centre of the driving axle, differs and is a new improved version.

Instead of the two arms fixed to the axle (see figs. 217, 218 and 130 of Cde. indiv.) and engaging in the articulations of the two opposite angles of the quadrilateral frame (Oldham joint, as shown in figs. 219 and 231), there are now five

([134]) Electric services on the Netherlands State Railways, installed successively since 1927, DC, 1 500 V., have so far been restricted to motor sets running between large towns. Express and goods trains have been hauled by steam locomotives. Electric and diesel-electric sets have nose-suspended motors only. — Previously, the Rotterdam-Scheveningen line was single-phase.



Cliché « Revue Polytechnique Suisse SBZ ».

Fig. 228. — Steam locomotive, type 2-C_0-2, No. 232-P1, French National Railways SNCF (Nord), without tender and streamlined cowling, with SLM-universal axle drive.

operating through coil springs on to an annular ring. In other words, the frame is replaced by a spring transmission. The two main geared rims have oblique teeth (fig. 235) and together provide V-shaped teeth. We shall return to this very recent application in the Appendix.

Fig. 235 shows a part set of wheels, ready to receive the body slung above; on the middle two driving axles (3rd and 4th from the left) the V shape of the main gear wheel teeth (in two parts, divided vertically) as well as a part of the five rectangular openings (corresponding to the five transmission arms mentioned) in the rings enclosing the mechanism, can be seen. Fig. 236 shows part of locomotive No. 1001 during the mounting of the electrical equipment (at the Oerlikon Works, Zurich) ([135]); the mounting of one of the traction motors is in progress, this being done from outside, through the removable frames shown in figs. 234-237. This mounting and removal of the traction motors is very simply carried out from the exterior, and constitutes one of the advantages of the mechanism (see fig. 139 of **Cde. indiv.**).

Finally fig. 237 shows this locomotive 1001 ready for service.

The principal characteristics of this 1001 series of N.S. locomotives are :

Length over buffers	16.22 m. ($53'2^{13}/_{16}''$)
Total wheelbase . .	11.89 m. ($39'$)
Rigid wheelbase (between centres of bogie pivots) . .	8.9 m. ($29'2^{1}/_{2}''$)
Max. width of body.	2.95 m. ($9'8^{1}/_{8}''$)
Height of roof (from rail level and excluding pantographs and seating)	4.15 m. ($13'7^{13}/_{32}''$)

([135]) See *Neue Zurcher Zeitung*, Zurich, technical number 26, (956), 5 May, 1948, with notes on electrified lines of the Low Countries, 6 figs.

Weight of mechanical parts . . .	68 tons (66.92 Engl. t.)	Weight in working order	100 tons (98.42 Engl. t.)
Weight of electrical parts	31 tons (30.51 Engl. t.)	Adhesive weight (18 tons per driving axle)	72 tons (70.86 Engl. t.)

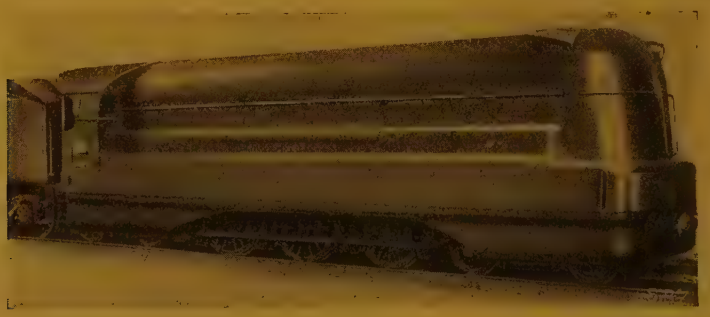


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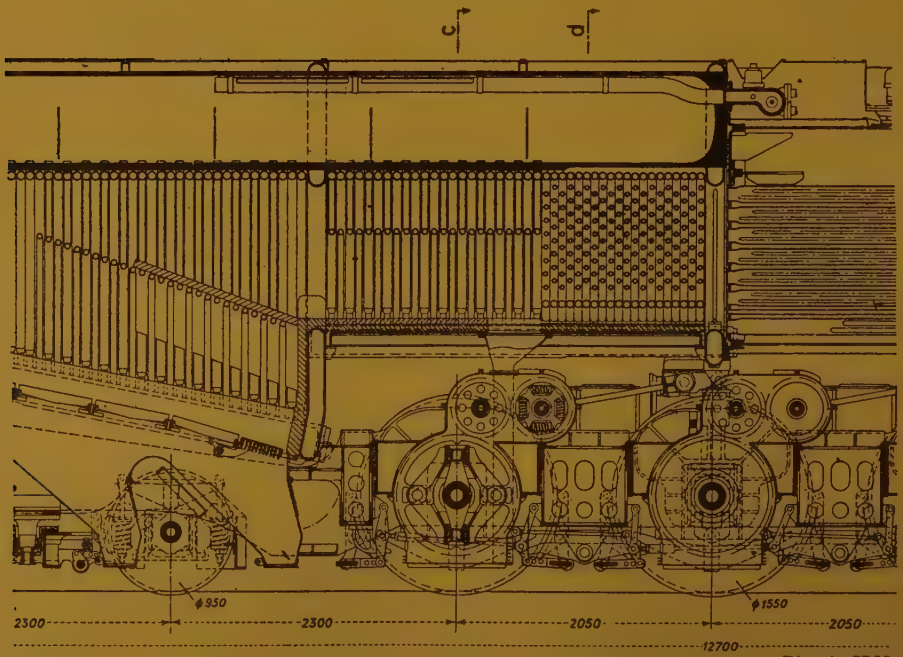
Fig. 229. — Locomotive in fig. 228, with streamlined casing and tender (partly shown).



D'après SLM.

Fig. 230. — Part section of the axles of locomotive in figs. 228-229, showing the arrangement of the gears and individual steam motors. The letters *c* and *d* refer to fig. 232 (section).

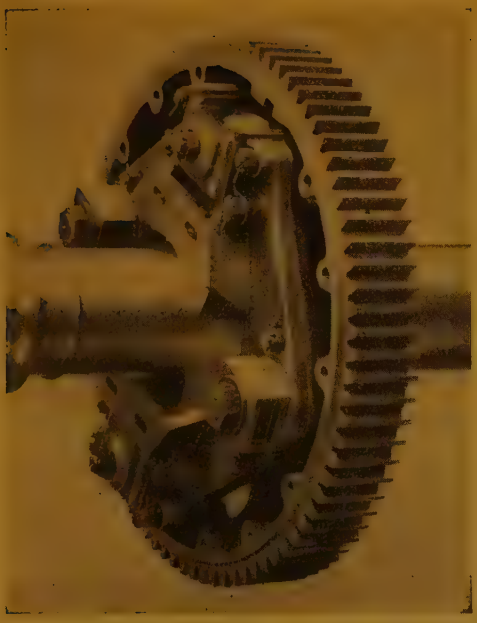


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Fig. 231. — Driving mechanism and half geared rim of locomotive in figs. 228-230 (see fig. 219).

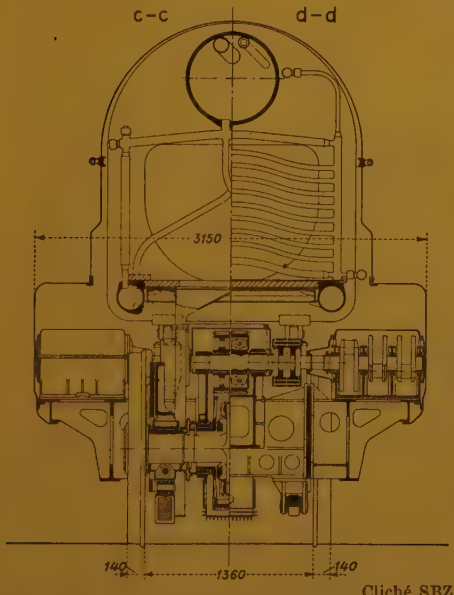

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Fig. 232. — Transverse section through a driving axle and an individual steam motor of the engine in figs. 228-231. For position of sections, see fig. 230.

Gear ratio	1:3.56
Hourly rating at armature . . .	4 500 H.P.
Corresponding tractive effort at rail, at a speed of 102 km./h. (63 m.p.h.)	11 400 kgr. (24 338 lbs.)
Max. tractive effort	18 000 kgr. (39 683 lbs.)
Max. speed in service	160 km./h. (100 m.p.h.)

Motor coupling : series; series/parallel; parallel.

To conclude Chapter V, mention may be made of a new variation of this mechanism, with floating rings, in this case set near one of the wheels (instead of in the centre of the axle), used on the prototype of an experimental locomotive for single-phase, 20 kV. current, at the industrial frequency of 50 cycles (see figs. 11 and 12 and page preceding these two figures, righthand column), C_o-C_o type, No. 6051, of the SNCF (see

Cliché SBZ.

Fig. 233. — Body of cast steel for drive and gears of locomotive in figs. 228-232.

fig. 238) at present under construction in the same Works as the Netherlands locomotives mentioned [136].

This new arrangement will be referred to in the Appendix, as will the prototype locomotive, which can also operate, although at somewhat reduced power, on direct current 1 500 V.

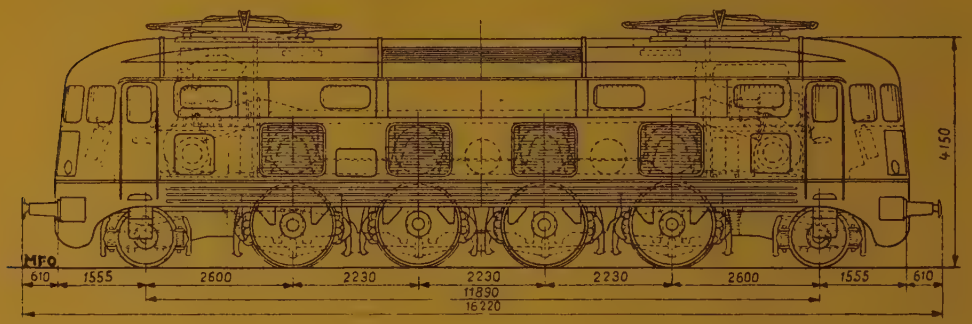


Photo Oerlikon-SLM.

Fig. 234. — Dimensioned sketch of locomotives 1A-AA-A1, series 1001, 160 km./h. (100 m.p.h.), 4 500 H.P., Netherlands State Railways, 1948.

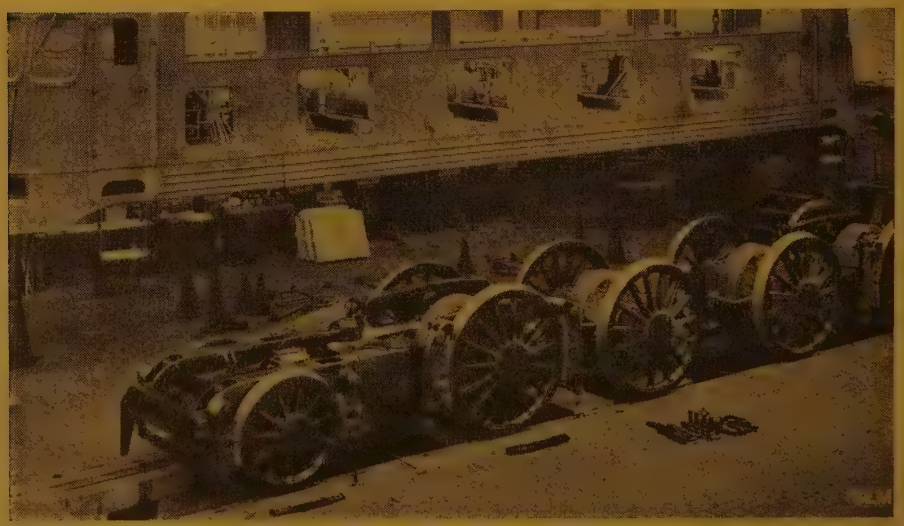


Photo SLM-Winterthur.

Fig. 235. — Part set of wheels, ready to receive the body, of locomotive in fig. 234. The V-shaped teeth of the gear rims can be seen.

([136]) See *Revue Générale des Chemins de Fer*, Feb. 1948, « La Traction électrique par courant monophasé à 50 périodes », L. ARMAND et M. PROT, 8 p. and dia. — See also back of leaflet mentioned under ([135]).

Photo Oerlikon.

Fig. 236. — Mounting a motor in locomotive shown in figs. 234-237.

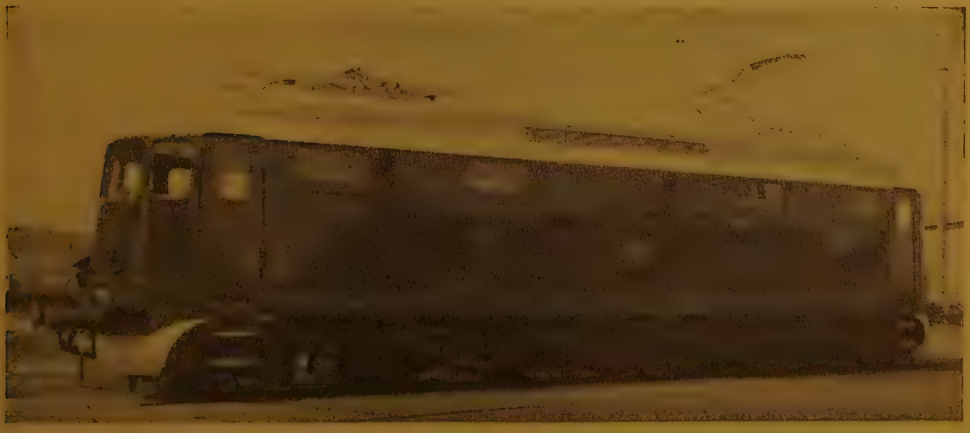
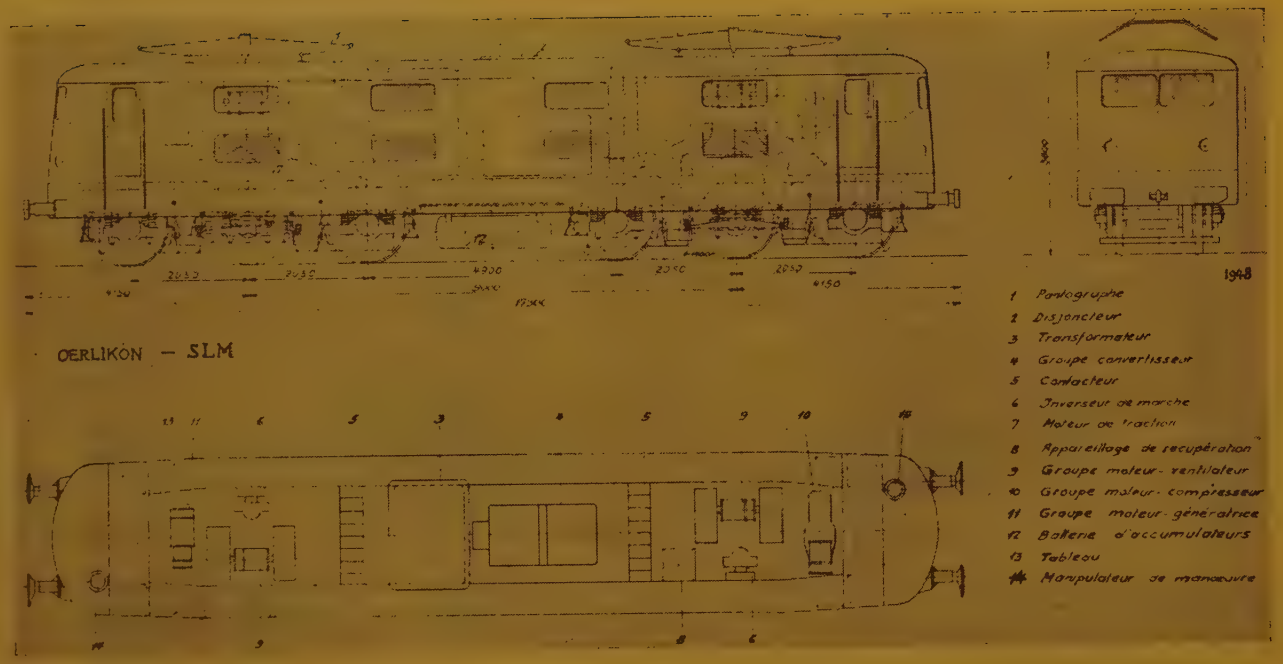


Photo Oerlikon.

Fig. 237. — Locomotive, series 1001, Netherlands State Railways, figs. 234-236, ready for service.



Plan Oerlikon-SLM.

Fig. 238. — Dimensioned sketch of experimental locomotive (prototype C_0-C_0, 6051) single-phase, 20 kV., 50 cycles and 1 500 V., DC, French National Railways SNCF, now under construction (Oerlikon SLM).

Explanation of French terms.

1. Pantograph.
2. Circuit-breaker.
3. Transformer.
4. Converters.
5. Contactor.
6. Reversing gear.
7. Traction motor.
8. Regeneration equipment.
9. Motor-ventilator group.
10. Motor-compressor group.
11. Motor-generator group.
12. Batteries.
13. Table.
14. Regulator.

Chapter VI.

DRIVING MECHANISMS WITH CARDAN-JOINT HOLLOW SHAFT AND FLEXIBLE STEEL DISC OR QUADRILATERAL LAMINATED OR PLATE COUPLING.

Introduction.

During the last 5 or 6 years, three quite new arrangements with hollow shaft and *cardan joints* have appeared and been the subject of different applications, in Switzerland and in other countries. These three mechanisms are of Swiss origin, and in order of appearance are :—

1. The disc-drive mechanism by Brown Boveri.

2. The Secheron laminated mechanism.

3. The Oerlikon plate mechanism.

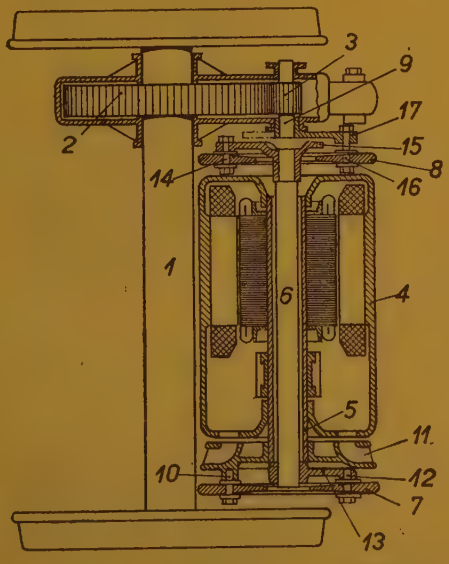
They are described successively as follows :—

1. *Mechanism with flexible steel discs.*

This mechanism, developed by Brown Boveri, has been used, experimentally, since 1938 on one axle of a Swiss Federal Railways locomotive, then on a series of tramway motor vehicles, new B_0-B_0 express locomotives of the Lötschberg Railway and on engines of other systems, on which we shall comment later.

The disc mechanism has been designed by successive developments of the cardan joint transmission with Hardy coupling for tramways ([137]). It can be described as follows (see the diagrammatic sketch, fig. 239, from which the axle bearings are omitted) ; the couple provided by the gear wheel 2, mounted rigidly on the axle 1, in the same housing as the pinion 3, is transmitted from the motor 4, to the pinion through a cardan joint 15/17, which, being set in front of the gears, may be of smaller dimensions.

The hollow armature shaft 5, of the motor transmits the couple successively through the driving pin 10, the flexible



Brown Boveri

Fig. 239. — Diagram of disc mechanism, railcar type.

([137]) See *Brown Boveri Revue*, Switzerland, Oct./Nov. 1945, p. 332 (special number dealing with electric and thermo-electric traction). Fig. 4 of this number shows the 4 successive developments *a*) to *d*).

disc 7, the driving pin 12, the torsion bar 6, the flexible disc 8, with driving pins (14 and 16 and cardan joint) to the shaft 9, of the pinion 3, already mentioned. The substantial gearcase, in the bearings of which runs the axle, is partly suspended since it rests (right-hand side of the sketch) flexibly on the bogie frame. The motor, by reason of its hollow armature shaft, through which passes the torsion bar 6, is fully suspended; the two transmission discs and the cardan joint, almost entirely suspended.

The principal advantages of this mechanism are :

1) elimination of all lubrication for the transmission details (apart from the gears themselves);

2) reduced weight and volume;

3) dimensions may be arranged to suit a lower-powered couple, since the cardan

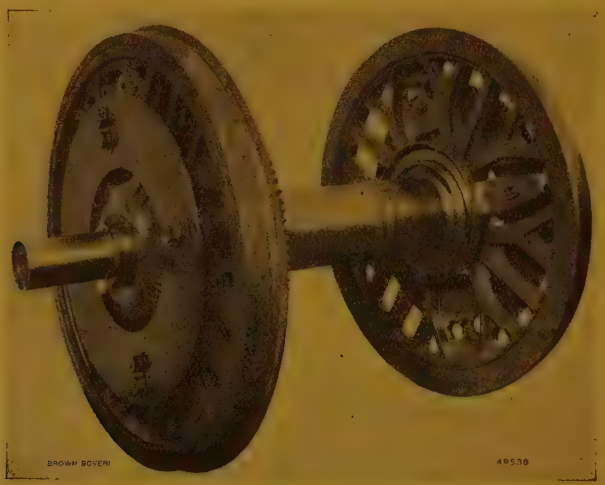


Fig. 240. — Axle fitted with first Brown Boveri disc trial mechanism, fitted experimentally in 1938 to 2-C_o-1 loco. No. 10264, Swiss Federal Railways.

Photos Ad.-M. Hug.

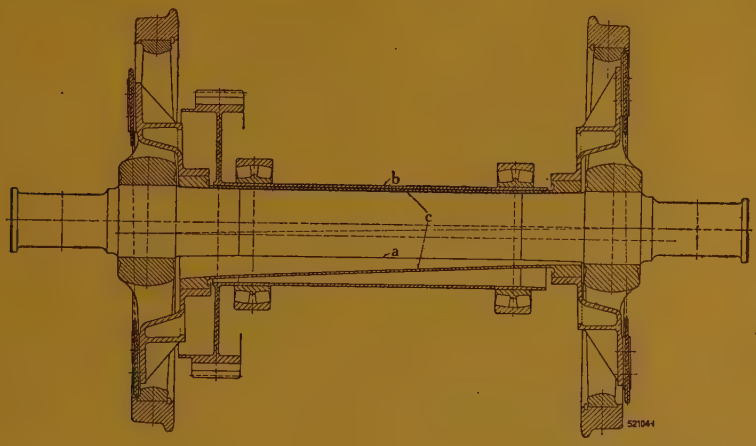
Fig. 241. — Same axle as fig. 240. Left — seen from opposite side (gear wheel). Right, the axle under the locomotive.

group is introduced between the motor and the gears.

The following applications of the mechanism have been made :

A) *to locomotives.*

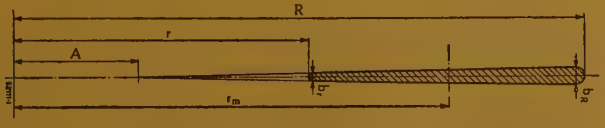
Fig. 240 shows the first trial arrangement, fitted to an axle of locomotive Ae $^3/_6$-III (2-C_0-1 type), No. 10264, during 1938 (transferred in 1944 to a similar locomotive, No. 10263) [138]; the two photographs forming fig. 241 show the same axle, seen from the opposite side, and fitted to locomotive No. 10264.



Plan Brown Boveri.

Fig. 242. — Cross-section of axle in figs. 240 and 241, showing the maximum displacement of the hollow shaft in relation to the frame [139] :

a = axle;
b = hollow shaft;
c = intermediate shaft carrying the disc fittings.



Plan Brown Boveri.

Fig. 243. — Trapezoidal section of disc of drive shown in figs. 240-242 [139] :

R = outer radius of disc;
r = inner radius of disc;
r_m = average radius;
A = distance from axis of ideal point of contact of the trapezoidal section faces;
b_R & b_r = inner and outer thicknesses of the disc.

[138] These two locomotives form part of the series 10261 to 10271 of the Swiss Federal Railways, with a carrying bogie and bissel, they are provided with Westinghouse quill drive, used at first (1922/24) by Secheron. See figs. 34 and 36, also 72, 73 (left-hand side), 74, 76 ($1B_0 1+1B_0 1$), 77 and 78 (1-C_0-1) of **Cde. indiv.**

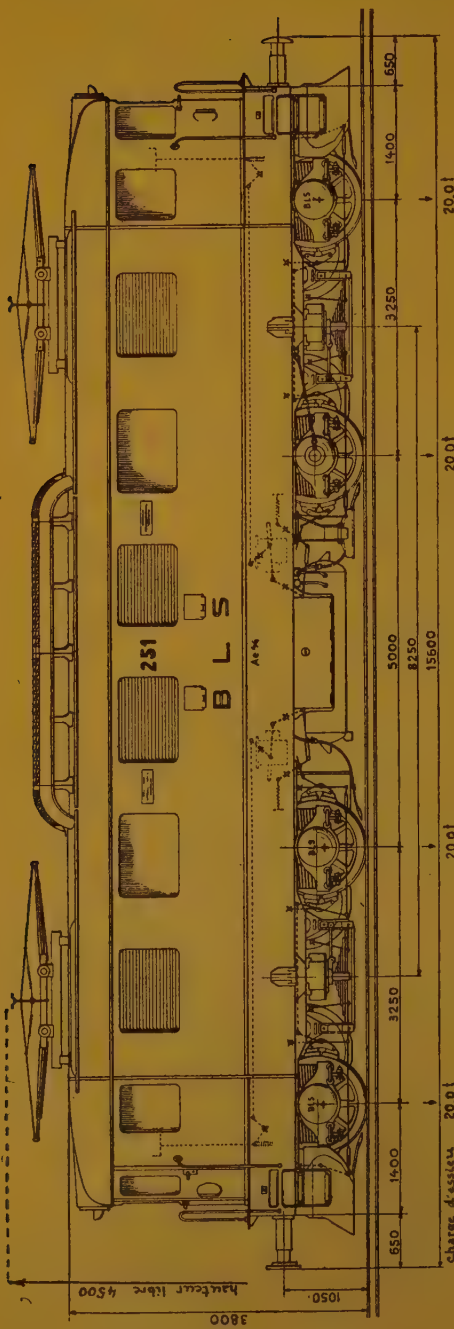


Fig. 244. — Dimensioned sketch of series 251 locomotive of the Lötschberg Railway, BLS, Switzerland. Type B_0+B_0, 4 000 H.P., 125 km./h. (77 m.p.h.).

This first application was really a kind of flexible floating ring with cardan joints rather than a true disc, as will be seen from the two figures mentioned. The trial arrangement is outside the wheels, the hollow shaft driving pins passing through apertures in the wheel centre. The motor is set above the axle. Gears are always unilateral with disc mechanism ([139]).

Figs. 242 and 243 show, respectively, the same axle in section (in the position of maximum displacement of the axle upwards, in relation to the bogie frame) and the coupling disc (flexible floating ring) of trapezoidal section. These two diagrams are included to explain the progressive development of the mechanism.

The following application, on a large scale, with discs inside the wheels but on either side of the *motor* and placed *alongside* the axle (as in the diagram forming fig. 239) is that on the Ae $^4/_4$ locomotives, series 251, type B_0-B_0, of the Bernese Alps, Berne-Lötschberg-Simplon, BLS (Switzerland), already mentioned on several occasions ([140]).

Fig. 244 is a dimensioned diagram of this type of locomotive, the characteristics being as follows :

Length over buffers	15.6 m. ($51'2^1/_8''$)
Total wheelbase . .	11.5 m. ($37'8^{21}/_{16}''$)
Bogie wheelbase .	3.25 m. ($10'7^{31}/_{32}''$)

([139]) For a detailed description of this trial mechanism, see *Brown Boveri Revue*, Switzerland, Oct. 1940, pp. 203-208, 11 figs. and diagrams, etc. The engine in note [1]) of p. 204, was originally No. 11000, type $1B_01+1B_01$, shown with its drive mechanism, in figs. 147 to 149 of **Cde. indiv.** The locomotive shown in fig. 146, No. 11301, no longer exists.

([140]) See *Brown Boveri Revue*, Oct./Nov. 1945, pp. 329-341, 25 figs., tables and diagr., W. LÜTHI. — *Revue Polytechnique Suisse SBZ*, Zurich, 4 May, 1946, F. GERBER, BLS, « New B_0-B_0 express locomotives of the Lötschberg line », pp. 218-225, 15 figs. and diagrams.

Distance between centres of bogie pivots	8.25 m. (27′ $^{27}/_{32}$″)
Wheel diameter	1 250 mm. (4′ $1^{7}/_{32}$″)
Weight of mechanical parts (inc. gears)	44.35 tons (43.63 Engl. t.)
Corresponding tractive effort at rail, at 76 km./h. (47 m.p.h.)	14 200 kgr. (31.304 lbs.)
Max. starting tractive effort	22 000 kgr. (48 502 lbs.)
Max. speed in service	125 km./h. (77 m.p.h.)

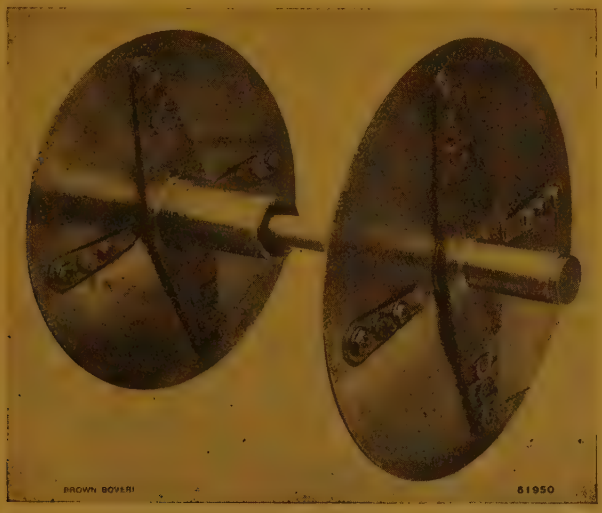


Fig. 245. — Complete driving mechanism (seen from pinion side) for axle of locomotive in fig. 244. By comparison with fig. 246, the following can be seen : left, the sleeve 1, threaded to the armature; engaging in this sleeve, the shaft 6 through the armature; right, the supporting shaft 11 (separated from the shaft 6, and connected to it by the disc and its fittings) of the pinion. All this group is therefore placed alongside the axle and its axis (at rest) is identical with the motor axis (not the axle). The varying thickness of the fixing arms can be seen.

Weight of electrical equipment (inc. disc mechanism).	34.25 tons (33.70 Engl. t.)
Tare	78.6 tons (77.358 Engl. t.)
Weight in running order	80 tons (78.73 Engl. t.)
Axle load	20 tons (19.68 Engl. t.)
Hourly rating (4 × 1 000)	4 000 H.P.

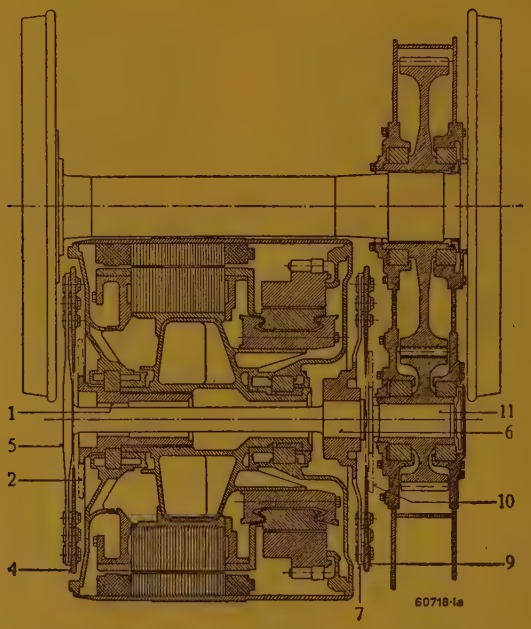
The first two locomotives, Nos. 251 and 252, were put into service on the 14th November, 1944 ([141]), and the 27th March, 1945, respectively; between them they had run, up to May, 1948, about a million km. (630 000 miles) in the 3 ½ years.

As regards the following pair, locomotive No. 253 was put into service at

([141]) See *CFF Bulletin*, Berne, Jan. 1944, p. 13, 2 figs.

the end of April, 1948; the fourth, No. 254, is still under construction. It may be recalled that the BLS operates on single phase current at 15 kV., $16^{2}/_{3}$ cycles.

There is no doubt that these locomotives have so far given satisfaction. 2 driving bogies only, B_0-B_0, for this power and speed (142). With regard to the behaviour of the disc mechanism in this BLS application, a definite statement can hardly be made, the engines being indeed a completely new arrangement. The Lötschberg line is, however,



Brown Boveri.

Fig. 246. — Section of complete group of a driving axle of figs. 244 and 245 (see also figs. 247 and 248), through a plane at an angle from the horizontal, through the centre lines of the motor and axle. The journals are not shown. See text for explanation of figures.

They are the first express locomotives for both main and mountain lines, both powerful and light, with a tare of 80 tons and 4 000 H.P., the ratio is only 20 kgr. (44 lbs.) per H.P. They are also the first engines of this type with of the opinion that, in view of mileages obtained with the first two during more than three years, it is very satisfactory that no defects have so far arisen, in spite of the heavy duty to which they have been subject. Frequent inspection

(142) See note (114) and publication referred to.

has shown neither wear nor deformation, of any kind. The driving mechanism has not, so far, been overhauled.

Fig. 245 shows the disc-drive mechanism, as used on the BLS locomotives, and fig. 246 a horizontal section (inclined at about 20°, since the plane passes through the axle and motor axles) of the complete assembly of a driving axle (see fig. 239). As will be seen in figs. 244 and 247, the motors are not placed above the axle but, as already stated, at the side nearer to the bogie pivot, on both sides (143). The discs

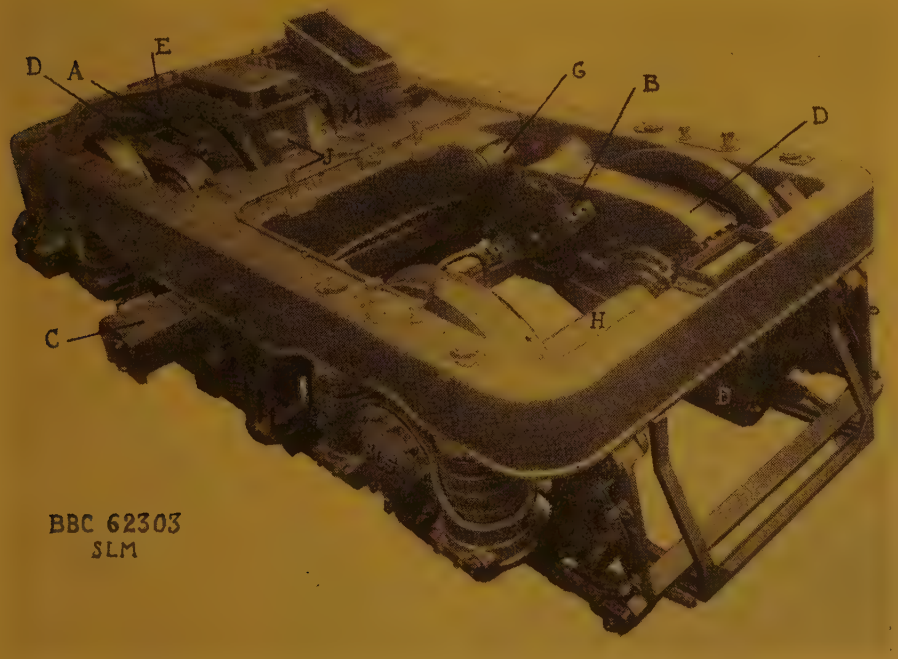


Photo Brown Boveri.

Fig. 247. — Bogie of locomotive in fig. 244. One of the motors is in position, the discs A will be seen; the other motor is not in place, but the fixing arm B for the disc and the side of the case can be seen.

A = flexible disc (9 — fig. 246);
B = fixing arm (10 — fig. 246);
C = body bearing plates (see fig. 248);
D = case;
E = bracket for motor on bogie frame;
G = flexible suspension rod for case on bogie frame;
H = driving axle;
J = bolts for fixing motor to middle bearer of bogie frame;
M = traction motors.

(143) See also figs. 185 and 186 and remarks under item 19).

are, in this case also, ring type (as fig. 240) but the centre opening is very much smaller. It can be seen at the right of fig. 145.

Fig. 246 can be described as under (compare with fig. 245). The couple developed by the motor is transmitted to the flexible disc 4, through the sleeve 1 (screwed and keyed to the inside of the armature) and the driving arm. A second arm, 5, set at 90°, drives a shaft 6, at the end of which is fixed, by means of the arm 7, a second disc 9. This, in turn, through the arm 10, carries the axis of the pinion 11, which engages with the gear wheel mounted on the axle. The motors are mounted rigidly in the bogie frame (E and J of fig. 247) which is carried on springs borne by the two axles each with one gear wheel. The function of the flexible discs is therefore to allow a relative movement between the axle and the motor resulting from the play in the springs and suspension. The gear case is in two parts and of robust construc-

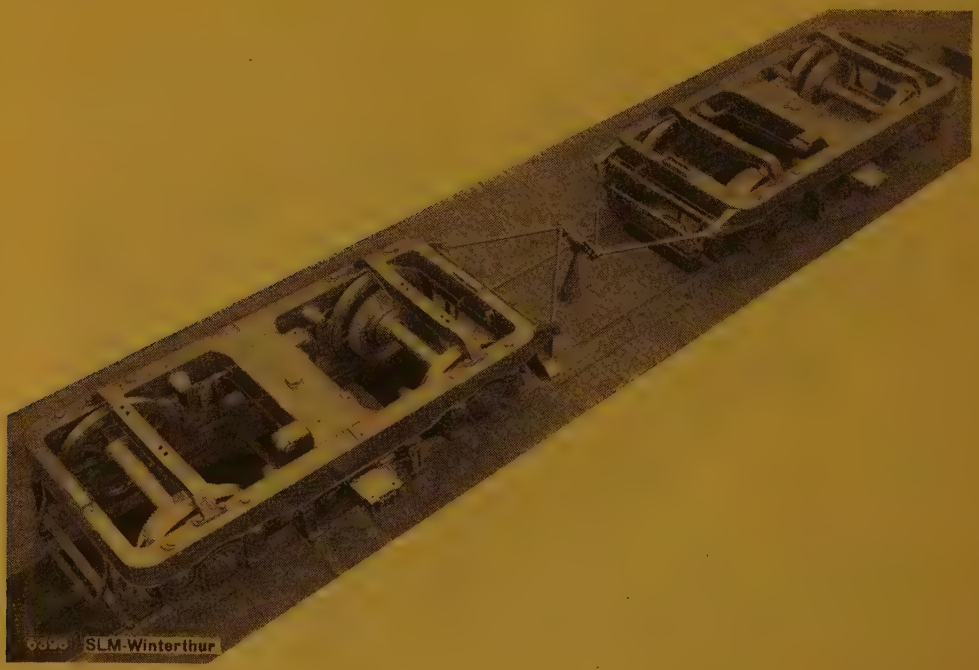


Photo SLM.

Fig. 248. — Set of 2 bogies of figs. 244 and 247. Link rigging for guiding through curves can be seen in the centre, the two triangles are connected by a spring acting transversely. The rigging is supported at the centre by the body : in this photograph it is supported specially. The two bogies are without motors, but the main gears can be seen.
The rectangular pieces seen on the bogie headstocks are for body support in conjunction with the device for extra adhesion in starting.

tion, since it is designed not only to protect the gear wheels, but particularly to support the self-aligning roller bearings of the pinion and gear wheel. This gear-case, which gives a very good mount for the gears, rests partly on the axle and partly from a rod and yoke mounted on « silent-blocs » on the bogie frame (G of fig. 247). Thus arranged, this disc transmission is, as already stated, of very reduced weight and volume; as it has no parts subject to friction, no lubrication or periodical maintenance are necessary. Moreover, as the intermediate shaft, apart from a small amount of flexion (when in a slightly oblique position as a result of the play of the axle) ([144]) carries a torsion couple, it can be relatively light. Further, this couple is fairly low, since the shaft is located between the motor and the reduction gear and therefore rotates at the higher-motor-speed, this being contrary to the general arrangement in use in which the shaft follows the reduction gear. As will be seen in fig. 246, these motors are therefore without true shafts, the hollow part of the armature shaft serving for the purpose. We shall deal with this construction again later.

Despite the increased hourly rating of each motor (1 100 H.P.), the wheels are comparatively small (1 250 mm. diameter) and light.

This description, in certain directions, repeats what has already been said earlier in this Chapter, but this has been done for clarity.

Finally, figs. 247 and 248 show the bogies of these locomotives, fig. 247, with one of the motors in place and one not mounted; on the left, against the wheel, is one of the discs. Fig. 248 shows the two bogies with their triangular coupling rods (this rodding will be described later) omitting the motor groups with their discs.

This bogie can be described as follows. The electrically-welded tubular frame rests on coil springs supported on the axlebox tops. Cylindrical guides with bronze sleeves, fixed under the frame, engage in the springs and are fitted with cylindrical « silent-blocs » which absorb lateral shocks. The body of the locomotive does not rest directly on the bogies, but on two swing bolsters carried by laminated springs, slung from the bogie frame by the rods which are clearly shown in fig. 247. The pivot is fixed to the middle bearer of the bogie frame, and carries tractive and braking efforts, via the seating in the bolster, to the body of the locomotive and thence to the draw- and buffing-gear. As the pivot bearing socket in the bolster has very little lateral play, it can only transmit an effort along the line of the track, not a transverse one.

A link arrangement (transverse spring = small cylinder in the centre of fig. 248) has been provided for the two bogies. This arrangement only comes into operation on curves; it can be easily fixed or disconnected, and is supported in the middle by the body of the vehicle. The behaviour of the locomotive when running can thus be tested with the bogies linked or uncoupled. The coupling provides an excellent alignment of the bogies in curves.

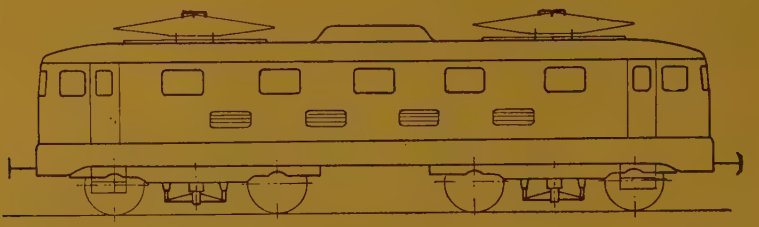
As regards *braking* of this special type of locomotive, we may state that as the locomotive has a maximum speed in

([144]) There is consequently a warping of the discs and the resultant forces, being transmitted by the torsion shaft, require the latter to be protected from flexion.

excess of 110 km./h. (68 m.p.h.) (up to 125 km./h. [77 m.p.h.]), the normal mechanical brakes, i.e. Westinghouse automatic, graduable and hand, have been supplemented by an additional device, type R, by means of which the brake-block pressure is automatically increased when the speed indicator passes 80 km./h. (50 m.p.h.). This increased pressure is necessary in order that the prescribed stopping distance is observed when braking at high speeds.

locomotives with disc drive, it may be mentioned that amongst details which will be given in the Appendix is the fact that specific head resistance (measured at a speed of 50 km./h. [31 m.p.h.]) is only 5 kgr./ton. (11 lbs./t.) compared with 9-12 kgr./ton. (19 to 25 lbs./t.) with the previous large locomotives of the BLS ($1C_0+C_01$ and 1-E-1).

We now come to the three similar type locomotives ordered in 1946 by the Bel-



C.F.B.

Fig. 249. — Sketch of B_0-B_0 locomotives for 3 000 V. DC, series 121.001, Belgian National Railways, 2 800 H.P., 125 km./h. (77 m.p.h.). Brown Boveri disc drive.

It must be remembered, however, that the friction of the blocks on the wheel increases greatly as the speed drops; if the high pressure is maintained at low speeds the wheels will skid and possibly cause flats on the tyres. For this reason the R type device is controlled so that brake block pressure is automatically reduced to its normal value when the speed falls to 40 km./h. (25 m.p.h.) ([145]).

The locomotives were designed, and the electrical equipment built, by Brown Boveri and the mechanical parts were supplied by SLM Company of Winterthur.

To complete the particulars of these

gian National Railways (CFB-BSM) and which are at present under construction ([146]).

Fig. 249 is an outline diagram of these B_0-B_0 locomotives, which will be numbered 121.001-121.003 and will have the following characteristics :

Length over buffers	16.3 m. ($53'5^{13}/_{16}''$)
Total wheelbase . .	11.6 m. ($38'^{0}/_{8}''$)
Bogie wheelbase . .	3.6 m. ($11'9^{6}/_{8}''$)
Distance between centres of bogie pivots	8.0 m. (26'3'')
Wheel diameter . .	1 350 mm. ($4'5^{1}/_{8}''$)
Axle load	20.5 tons (20.27 Engl. t.)

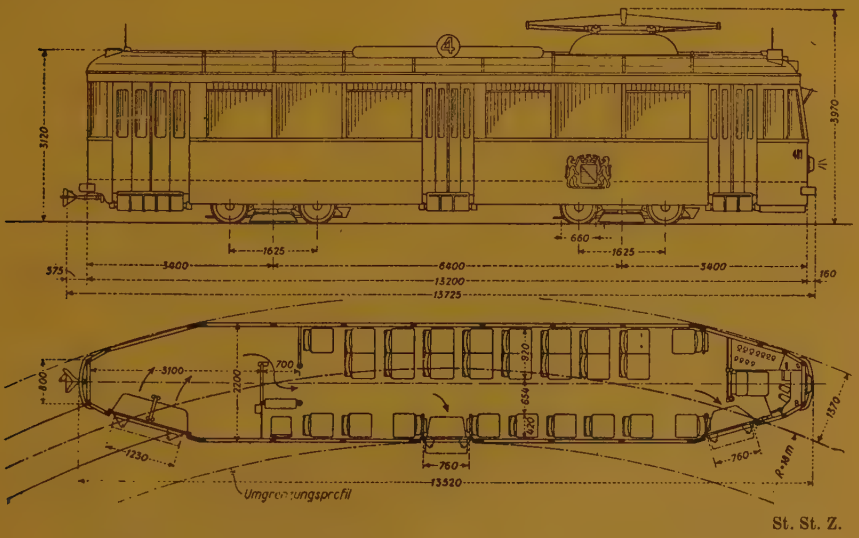
([145]) See remarks on pages with figures 81 and 85.

([146]) See *Brown Boveri Revue*, Switzerland, No. 1/3, 1947, pp. 46-47 and fig. 86.

Weight in working order	82 tons (80.70 Engl. t.)
Hourly rating at rail (4 × 700) (approx. 51 km./h. [31 m.p.h.]) . .	2 800 H.P.
Continuous tractive effort	11 500 kgr. (25 352 lbs.)
Max. speed in service	125 km./h. (77 m.p.h.)

Baden (Switzerland), with Brown Boveri disc transmission.

The bogies are of the same type as for the Ae $^4/_4$, series 251, BLS locomotives, but, as will be seen from the characteristics given above, with a larger wheel diameter and wheelbase. The three locomotives will be fitted with a mechanical anti-slip device (compressed air cylinders



St. St. Z.

Fig. 250. — Series 1501 railcar, Zurich Tramways (Switzerland), 200 H.P., 55 km./h. (34 m.p.h.).

As on the BLS locomotives mentioned earlier, draw and buffing stresses are transmitted by the body. The builders are :

Mechanical parts — S.A. des Forges, Usines et Fonderies, Haine St. Pierre, Belgium, the bogies being manufactured from SLM-Winterthur (Switzerland) ;

Electrical equipment — Brown Boveri, between body and bogie bolsters) ([147]).

The first of these 3 locomotives will probably leave the Works in April, 1949.

B) Application of the mechanism to *tramway vehicles*.

Amongst the series of new cars introduced by the Zurich Municipal Tramways, in what is the largest city in Switzerland, before the war (1939) within

([147]) See publication mentioned in note ([114]), p. 41 (right-hand column), for brief description.

the scheme for modernising and rationalising the transport system, especially the tramways, one of the most interesting is the series 401 (now 1501) and 1371, type Ce $^4/_4$, with bogies ([148]). The first two of these cars, Nos. 401 and 402, were put into service in 1941 and 1942; from 1943 to 1947 they were followed by 21 other units, bringing the total to 23 (Nos. 1501-1518 and 1371-1375).

Fig. 250 is a dimensioned sketch showing the general arrangement of the cars, the bogies of which are provided with the same Brown Boveri flexible disc transmission. The bogie assembly and various details are shown in figs. 251 to 254. This is an improved model, Brown Boveri « Simplex », the feature of which is that the motor housings comprise the frame of the bogie, this frame being suspended, on the one hand from the axles by half sets of laminated springs (seen in the four figures) and by the flexible cardan joint mechanism,

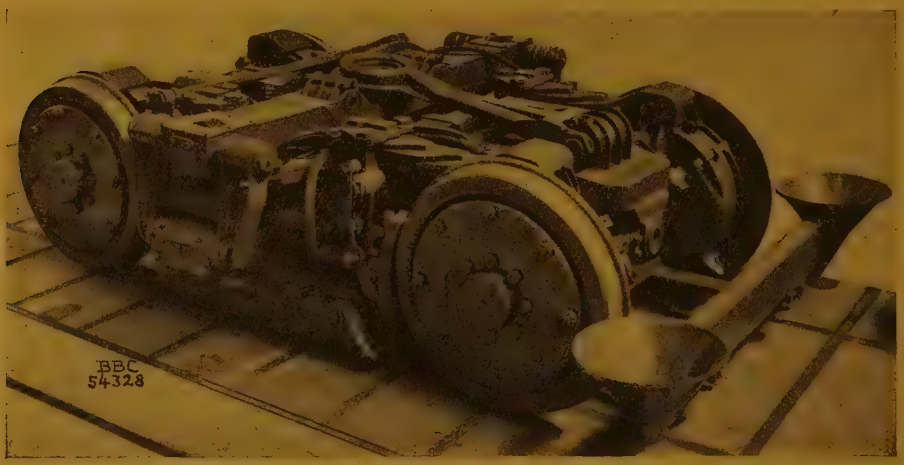


Photo Brown Boveri.

Fig. 251. — Complete bogie, 2 motors, disc and cardan drive, electro-magnetic rail brake, car in fig. 250. The funnels in the front are for sanding. SAB type flexible wheels (see figs. 252 to 255).

([148]) All new series, since 1928, of the Zurich tramways, are motor vehicles with two bogies and four driving axles : the modern series have been introduced since 1939. — See *Verkehrstechnik*, Berlin, No. 4, Febr. 1940, « Der neue vierachsige Triebwagen der Zürcher Strassenbahn », A. BÄCHTIGER. — *Revue Polytechnique Suisse SBZ*, Zurich, No. 20, May 1940, « Die moderne Strassenbahnen als wirtschaftliches Transportmittel », A. BÄCHTIGER. — *Verkehrstechnik*, Berlin, No. 4, 20/11/1940, « Neue Strassenbahnwagen in Zürich », J. ZÜGER. — *Economie et Technique des Transports*, Lucerne, 1940/41, « Die wirtschaftlichen und betrieblichen Vorteile der neuen Zürcher Grossraum-Strassenbahntriebwagen », J. ZÜGER, pp. 3-8, 7 figs. — *Neue Zürcher Zeitung*, « Beiblatt Technik », Zürich, 26/11/1941, « Der modernste Strassenbahnwagen Europas », A. BÄCHTIGER. — *Verkehrstechnik*, Berlin, No. 1, Jan. 1942, « Der neue vierachsige Leichttriebwagen der Zürcher Strassenbahn », A. BÄCHTIGER. — *Brown Boveri Mitteilungen*, Baden (Switzerland), 1942, pp. 62-64. — *Alluminio*, Milano, No. 3, May/June 1942, « Nuova serie di vetture leggere in alluminio delle Tranvie Municipali di Zurigo », Ad.-M. HUG. — *Verkehrstechnik*, No. 6, Bd. 24, 20/3/1943, « Die Grossraum-Triebwagen der Zürcher Strassenbahn », J. ZÜGER.

Photo Ad.-M. Hug.

Fig. 252. — Part view of motor emplacement, bogie in fig 251. The driving disc and arms can be seen.

on the other hand by the swing bolster on which the body is supported ([149]).

The arrangement of the disc mechanism is very similar to that of fig. 239. The bogies are of Brown Boveri manufacture.

The hourly rating of these cars is 200 H.P. (4×50) and 240 H.P. (4×60) respectively and the tares 11 and 13.4 tons; maximum speed in service 35 km./h. (21 m.p.h.). They are of the one-metre gauge which is used for all Swiss Tramways. This series of cars also offers another peculiarity, that the regulator and electric brake are not hand-controlled but are operated by two *pedals*, one for running and one for braking, as in a trolleybus.

We may also note, within the subject of unsuspended weight, which is given very great attention in modern Swiss tramway vehicles (and also in the United States), the SAB ([150]) sprung wheel system.

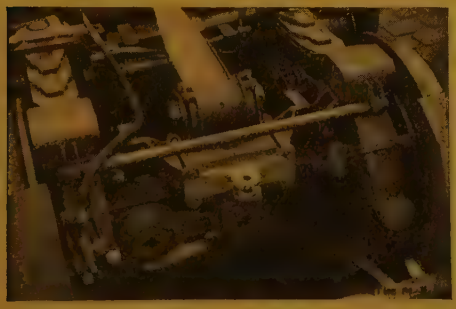


Photo Ad.-M. Hug.

Fig. 253. — Front view of locomotive in figs. 251 and 252, with gear-case and disc, but no motor.

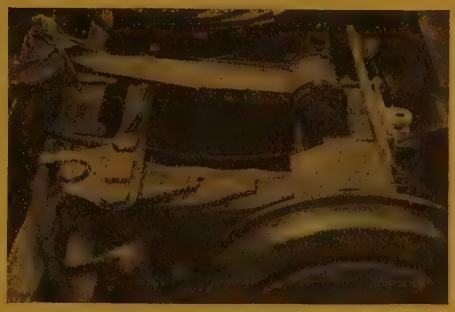


Photo Ad.-M. Hug.

Fig. 254. — Another view of bogie in figs. 251 to 253.

Fig. 255 shows the arrangement of these wheels. Other sprung wheel systems have been used on different Administrations in Eastern Germany (between the two wars) but apart from the SAB and American PCC (Presidents' Conference Committee, American Transit Association, ATA), none appears to have given

([149]) See earlier publications by Brown Boveri, regarding the Simplex bogie. — Also note ([148]).

([150]) Trade mark of « Svenska Aktiebolaget Bromsregulator », Malmö, Sweden, represented in Switzerland by Georg Fischer of Schaffhausen.

very lasting satisfaction ([151]). The SAB flexible wheels used on a large number of tramway vehicles (motors and trailers) in Switzerland have given complete satisfaction.

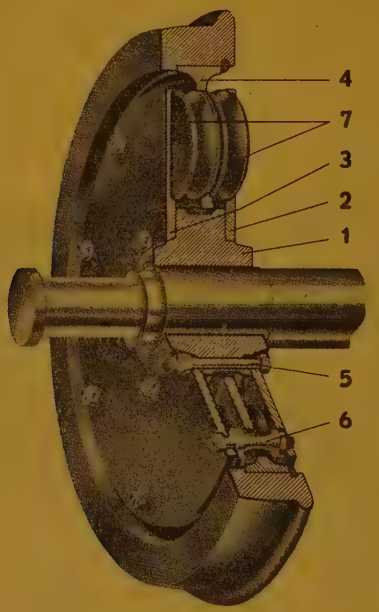


Fig. 255. — Diagram of SAB wheel used on bogies in figs. 250-254.

1 = wheel centre;
2 & 3 = cover plates and retaining plates for rubber discs (7);
4 = tyre retaining ring;
5 = fixing bolts for cover plates to wheel centre;
6 = spacing bolts for cover plates; these bolts are located between the rubber discs (7).

The construction of tramway motor vehicles in Switzerland is distributed amongst the various builders of this class : SWS-Schlieren (Zurich); SIG-Neuhausen (Schaffhausen); Schindler-Waggon, Pratteln (Bale), for the mechanical parts, and Oerlikon, Brown Boveri and Secheron for the electrical parts.

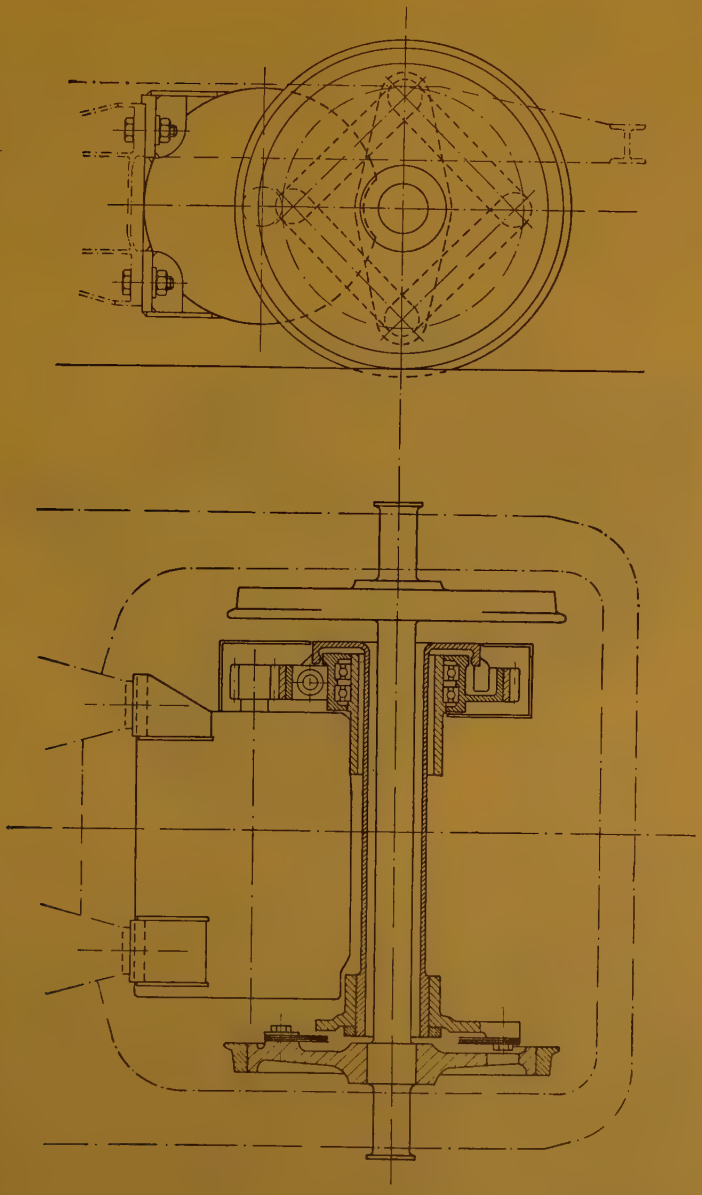
Other uses of cardan-joint mechanism will be referred to in the Appendix, and we will mention here only the Swiss undertakings at *Lucerne* (10 motor vehicles, Nos. 101-110), *Berne* (15 motor vehicles, Nos. 101-115) and *Bale* (54 motor vehicles, Nos. 401-454, series still under construction). It may also be remarked that in Switzerland alone, there are already 534 sets of disc drive, 226 of these being on cars at present under construction. With an annual mileage of about 50 000 km. (31 000 miles), the first tramway disc drives have already done some 300 000 km. (186 000 miles).

2. *Drive mechanism with hollow shaft, cardan joints and laminated coupling.*

Fig. 256 shows this arrangement diagrammatically, which was designed and built by Secheron (SAAS), and first used in 1947. It may be described as follows :

The cardan shaft is a hollow shaft on the axle. It is supported at one end by the leaf coupling (bottom of fig. 256) which connects it to the neighbouring

([151]) Regarding the SAB wheel, see *Economie et Technique des Transports*, Lucerne, Vol. 67, March 1947, pp. 24-25. — Concerning the PCC bogie and wheels, apart from American publications, there are *Verkehrstechnik*, Berlin (replaced now by *Verkehr und Technik*, Essen [Ruhr]), the article « Die neueste Entwicklung der Nahverkehrsbetriebe in Nordamerika », by Ad.-M. HUG, p. 174, Vol. of 1940. — A new SAGA system, developed by Pirelli of Milan, has recently been fitted on 30 modern cars, with PCC type bogies, built by Fiat of Turin and the « Compania Generale d'Elettricità OGE » of Milan, for the « Sociedad de Tramvias » of Madrid. It is too early to consider the behaviour of this type of wheel, which will be used this year on some tramway vehicles for Switzerland, by the Schindler-Waggon Co. Further reference will be made in the Appendix.



Cliché Sécheron.

Fig. 256. — Diagram of the unilateral cardan joint and laminated arm mechanism by Secheron. Drive is on the axle centre-line.

driving wheel. At the other end, this cardan shaft is carried by a boss, the form of which (driving wheel side) is a kind of ball and socket seen on the right in the gear-case (driving arms of the flexible gear wheel). The four sets of springs, arranged quadrilaterally as shown in fig. 256 (top), pivot on two points of fixing (upper and lower) to the diametrical arm of the hollow shaft

ter IV, page with fig. 189. Further reference will be made to this in the Appendix, but fig. 257 shows a traction motor of the bogies in question (V.H.B. and EBT, CFe $^4/_4$, series 141, fig. 187). The motor is seen from the end opposite to the pinion; on the left can be seen the bolt-holes for fixing to the bogie frame.

Contrary to the latest disc mechanisms, mentioned under 1) above, the flexible

Cliché Sécheron

Fig. 257. — Traction motor — railway type — with mechanism shown in fig. 256 (mechanism applied to 2 bogies of the car shown in fig. 187).

(shown at the top of fig. 256 and, partly; bottom right) and two lateral connections (left and right) to the driving wheel (bottom, left, of fig. 256).

This mechanism is therefore unilateral, as are the gears at the opposite end ([152]). It was used in 1947 on two bogies of the railcars shown in fig. 187 (corresponding text under 20) of Chapcoupling in this case is about the centre line of the axle and was the first trial application of disc mechanism for a locomotive (figs. 240-242).

Another drive by Secheron which we shall describe, also with cardan joints and laminated couplings, is bilateral (still with unilateral gears) and in the motor axis; it is shown in fig. 258 ([153]).

([152]) See *Bulletin Sécheron*, No. 19, 1947, pp. 19-20.

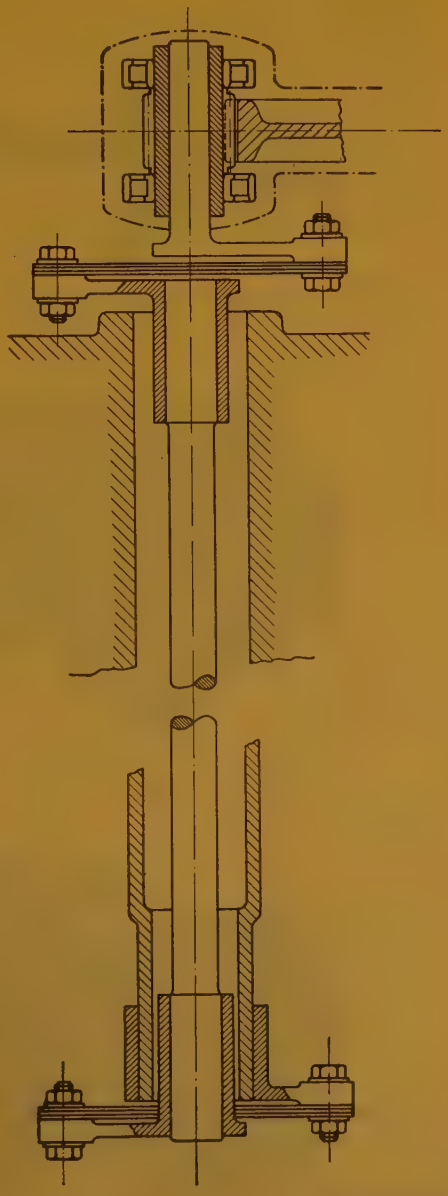
([153]) See *Bulletin Sécheron*, No. 19, 1947, p. 6, WERZ.

This is an arrangement used on the new light cars of the Neuchatel Tramways, Switzerland. Fig. 259 shows the torsion shaft with laminations and cardans and the pinion; this is for the lower power (4×50 H.P.) of 200 H.P. Fig. 260 shows two of these motors, coupled together (for bench test purposes only) by the cardan shafts and leaf couplings. Transmission is therefore bilateral, i.e. distributed over the two sides of the motor which carries the pinion, and in the motor axis. The similarity to the mechanisms already described, will be seen (see figs. 239, 252 and 253).

Fig. 261 shows one of the bogies of the Neuchatel cars mentioned ([154]) built by the SIG-Neuhausen Co. with torsion bar suspension. The wheels are of the SAB flexible type shown in fig. 255 [see note ([150])]. The body of these cars (including two driving positions) rests on the bogies by means of four flexible components composed of a coil spring round an oil brake, two of these elements being arranged, one on each side of each bogie. The spring bears on an equaliser slung from two rods at one end of the bogie bolster. This arrangement provides the desired transverse cushioning for the body; in addition, the rods are inclined in such a way that the body is automatically returned by its own weight, to its position on the axis of the bogies.

The pivot is fixed rigidly to the bolster and fitted flexibly to the middle beam of the bogie by rubber sleeves which provide a resistant couple to the rotation of the bogie and thus damp any oscillation of the bogie around its pivot.

The bolster rests on the bogie (fig.



Cliché Sécheron.

Fig. 258. — Bilateral Secheron mechanism, with cardan joints and laminated arms, drive on motor centre-line.

([154]) See *Bulletin Sécheron*, No. 19, 1947, pp. 28-29, P. Gaibrois.

Fig. 259. — Leaf (cardan joint) control mechanism of fig. 258, new light motor vehicles of Neuchatel Tramways (Switzerland).

Cliché Sécheron.

Fig. 260. — Two traction motors (tramway type, coupled, on test bench) showing mechanism in figs. 258 and 259.

Fig. 261. — Bogie with torsion bar suspension (SJG) and SAB flexible wheels for the new Neuchatel cars (see figs. 259). Motors shown in fig. 260.

261) by means of two conical rollers running on a suitably shaped surface of the bogie middle beam. The pivot does not carry any vertical force, but only horizontal forces. The bogie centre beam is carried by the axles by means of two pairs of arms fitted flexibly to the bogie by torsion bars, the free ends of which are fitted into the carrying bushes of the arms; these sleeves are fixed to the bogie centre beam supports by « silent-blocs ». Transverse rods fixed to the motor bodies transmit to the bogie the forces operating on the wheel treads and serve as safety hangers in the event of a spring breaking. The bogies are so constructed that cooling air for the motors is taken from the body sides to prevent too much dirt entering the motors. The use of rubber for the joints and the SAB flexible wheel discs assures the vehicle of smooth running, and reduces the necessity for lubrication to a minimum.

The traction motors are fixed rigidly to the centre casting and are therefore fully suspended. They drive the axle through a cardan shaft with flexible coupling (fig. 259) and a set of gears mounted in a gear-case. This, together with the axles, is the only unsprung mass. The flexible units of the coupling are of special high-tensile laminated steel. These cars are similar to that in fig. 250, but shorter : 12.18 m. (39′ $11^{19}/_{32}$″) over buffers, 11.40 m. (37′$4^{3}/_{4}$″) length of body, 5.60 m. (18′$4^{5}/_{8}$″) between bogie pivots and 1.65 m. (5′5″) bogie-wheelbase.

The mechanism in figs. 258-260 has been used on the new motor vehicles of the Rotterdam Electric Tramways (normal gauge) and will be fitted to 30 cars of the Geneva Electric Tramways. The bogies will be Schindler-Secheron type.

It will also be used, although naturally in a more robust form, on four motor brakes, type Fe $^{4}/_{4}$, of the Swiss Federal Railways, which have so far had nose-suspended motors.

Further reference will be made to various applications (still under constructions) in the Appendix, in which we shall also deal with the Oerlikon cardan and plate mechanism (3., see beginning of this Chapter).

(To be continued.)

[625 .142 .4 (.42)]

Concrete sleepers,

by N. W. SWINNERTON,

M.I.Struct.E. (Fellow).

(From *The Permanent Way Institution Journal and Report of Proceedings*, Vol. 66, Part 1, April 1948.)

The urgent need for an alternative to the wood sleeper, which was apparent during wartime, is again before us. Hence the suggestion to talk about concrete sleepers about which so much experimental work has been done and data collected. The subject, however, is not a new one, but it is difficult to decide what to say in a short time to meet the demands of all grades of the Permanent Way Staff. Concrete sleepers have been tried out from time to time on the Railways during the last thirty or forty years. These have been of multifarious types or designs although generally speaking, few of each type were laid down and invariably in track other than of primary character where high speeds prevailed. They were made of ordinary reinforced concrete.

Shortages of wood sleepers during the last war were anticipated and a thorough study of the concrete sleepers problem was set in motion in early 1941. A B.S.I. Committee was constituted to draw up a specification and members of the L.M.S. Research Department and of the Department of Scientific and Industrial Research instituted a comprehensive study of the forces to which concrete sleepers would be subjected and strain measurements were taken upon sleepers under traffic and maintenance conditions to assist in the design of an appropriate type or types.

Before embarking on the subject of concrete sleepers as they affect design and the permanent way staff, I think it is proper and should stimulate interest if a brief survey of the research work done and the results obtained is given you.

Firstly, some sleepers were laid in a siding on the L.M.S. so that experimental equipment could be tried out by the research staff and the methods to be employed on main line track decided upon for the collection of the necessary design data. Simultaneously with the outside work, various experiments with sleepers were conducted in the laboratories.

This preliminary work completed, several types of concrete sleepers were laid in the L.M.S. line between Tring and Cheddington which carries the heavy traffic from Euston to the Midlands and the North. The track is situated partly in chalk cutting and partly on tipped chalk embankment, and is on falling gradient of 1 in 330. The number of trains passing over was well over 100 per 24 hours, at speeds up to 70 m. p.h., mainly passenger trains, but with a few freight trains at fairly high speeds. The rail was 95 R.B.S. 60-ft. lengths with 24 sleepers per rail length and fitted with 2 bolts fishplates. A few lengths of track were laid with 131-lb. F.B. rail on some pre-stressed sleepers for comparison purposes.

To collect information respecting the forces to which a sleeper is subjected as well as the effects of such forces to form a sound basis for the design of sleepers was quite an extensive task, and all fundamental factors were compared with similar data, collected concurrently on wood sleepers under similar conditions.

The factors investigated were :

a) Strain measurements in Bull Head

rail supported by wood sleepers, concrete sleepers both normal and cracked.

b) Strain measurements in concrete sleepers at 3 positions in the concrete and 2 positions in the steel reinforcements and in 2 positions in wood sleepers.

c) Measurements of lateral track displacements under traffic of both wood and concrete sleepers.

d) Reaction between chair and sleeper i.e. the load transmitted from the rail to the sleeper by the chair.

e) Distribution of the reaction between chair and sleeper.

f) The distribution of pressure of the ballast reaction under the sleeper.

g) Vertical movements of sleepers on ballast which included the deflection of the sleeper under dynamic loading.

h) In the case of prestressed sleepers, slip of reinforcing wires was measured during curing of the sleepers and from time to time after laying in the track. The records were taken immediately after the track was laid and during consolidation and some data was taken on sleepers laid on ditched ballast bed.

a) *Strain measurements in B.H. rails.*

These measurements were taken with a modified de Forest extensometer which was fitted on the underside of the rail foot, this position being considered to be the best one to obtain the highest value in relation to variable sleeper support. The results indicate there is little difference in the stresses in Bull Head rails supported by concrete sleepers than figures previously obtained for rails supported by wood sleepers. The highest tensile stresses obtained ranged between 5 and 8 tons per square inch with an extreme value of 8.6 tons per square inch which compares closely with 8.1 tons per square inch for similar rails on wood sleepers.

(E = 13 000 tons per square inch and highest values due to coupled wheels.)

b) *Strain measurements in concrete and wood sleepers.*

These strain measurements were taken only on sleepers of the ordinary reinforced concrete type, and with the modified de Forest extensometer. Provision was made during the manufacture of the sleepers for the recording fitments to be welded to the reinforcing bars or cast in the concrete. The strain gauges were positioned where it was anticipated the highest readings would be obtained, i.e. on the steel and concrete directly under the rail and in centre of the sleeper on the upper surface.

The highest tensile stress in the steel bars was 26 200 lbs. per square inch, and was on the reinforcing bar at the bottom of the sleeper directly under the rail. The highest compressive stress in the steel bar was in the reinforcing rod at the top of the sleeper in the centre of the 4-ft. the ligure being 4 860 lbs. per square inch (probably end bound sleeper).

The greatest stresses in concrete were measured at a position on top of the sleeper in the centre of the 4-ft., the value being 730 lbs. per square inch tensile and compressive. The strain measurements on wood sleepers indicate less tensile and compressive stress values and results generally indicate the wood sleeper is less affected by the condition of the ballast packing, i.e. the wood sleeper bends under load and accommodates itself to irregularities in ballast packing.

c) *Lateral track displacement.*

The measurements indicate that there is no greater lateral displacement of track laid on concrete sleepers when compared with wood sleepers. The concrete sleepers tested were not specially treated on the underside, the surface being finished with a trowel, which is normal practice.

d) Reaction between chair and sleeper.

The load transmitted from the rail to the sleeper through the chair was ascertained by two types of gauges, one electric and the other mechanical, the former being used as a check on the latter. Both gauges were designed to fit between the rail and sleeper, the chair or baseplate being slotted so that it would slide off the sleeper and the gauge takes its place without disturbance of the track.

The results show that the chair reactions on the joint sleepers at the running on end of the rail for engine and tender wheels average about 8½ tons, but vary between 1 and 22 tons, with a very few higher than the latter figure. The loads due to coaches for the same sleepers average about 4 tons with a range of ½ to 13 tons.

The loads on other sleepers were of less intensity from approximately 15 % to 30 % less.

The variability of the loads was influenced by such factors as types of vehicle, speed, rolling and pitching of the vehicle and in particular by the condition of the sleeper packing.

The impact effect of the wheels passing across the gap accounts for the higher loads imposed on the joint sleepers.

The jumping of wheels at joints had the effect of producing two blows for every wheel on the running on joint sleeper. This imposes very severe conditions on the joint sleepers.

e) Distribution of the reaction between chair and sleeper.

Although the greatest loads occur immediately under the rail the results show that for design purposes the reaction is distributed uniformly over the area of the chair base or baseplate. This data was obtained by taking « ball impressions » on a series of steel plates, placed between the chair and sleeper. This apparatus was termed a « ball sandwich ».

f) Distribution of pressure under sleeper.

The method of measuring the distribution of pressure under the sleeper was carried out in the same manner as between chair and sleeper, « ball impressions » being taken over the whole length and width of the sleeper, involving nearly 200 impressions per sleeper.

As these records had to be taken from time to time under the same sleeper, particularly during consolidation of the track after laying it was necessary to avoid disturbing the ballast bed when inserting and removing the ball impression sandwiches. The selected sleepers were, therefore, laid on a board of the same thickness as the sandwich, wired to the underside of the sleeper and the board being carefully removed each time for the insertion of the sandwich, the track being jacked up for this operation. The depth of ball impression in the steel plates was measured and related in terms of load on the ballast.

This data was taken for sleepers laid on a ditched ballast bed and for sleepers laid on the usual flat bed; the ditch being a shallow trough, along the centre of the ballast bed, about 2′6″ wide and 2″ deep. This trough was considered in early days in the use of concrete sleepers, to avoid « centre-binding ».

The data obtained indicated that with ordinary stone ballast, shovel packed as necessary during consolidation and when consolidated measured shovel packed, the distribution of pressure was, generally speaking, over the length of sleeper where required. That is to say, the greatest pressure intensity was immediately under and adjoining the rails, or in other words over the areas of sleepers where packing is usually carried out, viz.: 1′3″ on each side of the rail.

There were, of course, occasional high pressure intensity spots, particularly during consolidation, due to irregular placement of stones and the like. After consolidation, the high pressure spots were due to imperfect packing of sleepers. When sleepers were laid on ditched tracks the pressure distribution was very little different than when laid on the usual flat ballast bed, but it was noticed the troughs were ultimately filled in by the pressure of the sleeper under traffic and therefore the bed cannot be said to have been a stable one. As troughing necessitates additional work when laying concrete sleepers and as no benefit accrues from it, normal practice was adopted.

g) Vertical movements of sleepers.

The measurement was taken by a deflectometer attached to an iron stake driven into the ballast to a depth and in such a way as not to be influenced by ballast pressure when loaded. The deflection was taken of the same sleeper on which the loads were taken so that the two factors could be related for the same axle load. The results indicated that the stiffness of the bed beneath the sleepers increases as the chair reaction goes up and stiffens as the track consolidates until a maximum stiffness is reached at about 6 months after laying.

h) To determine whether or not and to what extent the slip of the pre-stressed wires takes place, trammel measurements were taken from time to time during the making, curing and life of the sleeper. I shall have more to say about pre-stressing later on.

Designs of sleepers.

These can be classified into five distinct types, although there may be many designs of each type, as under :

1) Ordinary reinforced concrete transverse sleepers.

2) Spun concrete transverse sleepers.

3) Pre-stressed concrete transverse sleepers.

4) Pre-stressed and anchored concrete transverse sleepers.

5) Ordinary concrete (reinforced and non-reinforced) Pot sleepers, with or without tie bars.

When considering designs of concrete sleepers, one or two important factors had to be kept in mind. For instance, to maintain existing rail levels is essential from the point of view of overbridge clearances and coupling up old track to new during renewals, particularly where track is relaid piece-meal between trains. If rail levels differ to any great extent grading of the old track to the new lengths would add to the labour time and costs, packing the old sleepers to raise the rail level. It was, therefore, suggested the depth should be as near as possible that of the wood sleeper.

The width of the base was a dimension over which a deal of argument ensued, but to ensure a good ballast foundation a 10″ width was proposed for intermediate sleepers. If the bearing area of the sleeper is too small, more frequent packing of the sleeper is necessary. This recommendation is supported by subsequent experience.

The length of the sleeper has, in the design so far tried out and known to the author, varied between 7′6″ and 8′6″. The recommended length, by the author, was not to be more than 8′3″. If less than 8′3″ difficulty in maintaining adequate support from the ballast seemed to arise, in other words, more frequent packing is necessary. If, however, the sleeper is greater than 8′3″ and end bound sleeper conditions arise, the stresses in the sleeper under the rail are raised and cracking at this position may follow. It is suggested that failure of the sleeper by cracking under the rail is far more serious than from cracks which occur in the centre, due to centre bound conditions or from sagging.

Considerable difficulties were experienced by designers in meeting the above dimensions and at the same time in meeting the loading conditions on the sleeper. Designers, however, had another restricting condition to keep in mind, that of weight. To begin with, whereas an ordinary wood sleeper can be handled by 4 men, one of the same dimensions made in concrete requires 6 men to handle, so that designers start off at a disadvantage.

The loading conditions for the design of concrete sleepers have been laid down in a B.S.I. Specification No. 986 together with other relevant factors such as concrete mix, strength requirements, cover of reinforcing bar, etc.

Recommendations are also made in regard to methods of securing the chairs to the sleeper to meet varying traffic conditions.

The specification provided the dimensions and load data for sleepers to meet the traffic conditions on the various classes of track. For instance, a sleeper to meet the severe load conditions found in primary track has of necessity to be of greater strength than one required for tertiary track, where speeds and axle loads are much lower. The latest specification gives these requirements under four types and headings, as under :

Lightly worked sidings.

Goods lines and heavily worked sidings with speeds up to 20 m.p.h.

Tertiary track with speeds up to 45 m.p.h.

Secondary track with speeds up to 70 m.p.h.

Primary track with speeds up to 70 m.p.h.

Experience.

The first concrete sleepers te be laid down for trial between Tring and Cheddington were of the ordinary reinforced concrete types. With some designs, the chairs were secured to the sleepers by chairscrews driven into philplug inserts, with others the chairs were fastened by bolts. It was quickly apparent the philplug insert and chairscrew fastening was unsuitable for main line traffic although it has and will serve as a useful fastening for siding sleepers. It was also obvious that ordinary reinforced concrete sleepers, no matter what depth, were unsuitable for main line work. Cracks quickly developed in the four foot and later on under the rail, particularly in those with the philplug insert. It was noticeable too, there was insufficient cover of concrete on the reinforcing bars and stirrups and disintegration of the upper surface under the chairs resulted.

Ordinary concrete subjected to tensile stresses offers a very low resistance, and therefore designers depend upon the reinforcing bars to take these stresses, and as the bars and concrete have a different resistance factor, very much in favour of the bars, the concrete cracks when subjected to tensional stresses. You will recollect the tensional stresses recorded were very high, particularly under the rail, hence the failure of the sleeper in this position. Cracks in this position quickly widen, the bond between steel and concrete is destroyed and the concrete eventually breaks up under the impact of wheel loads.

In some designs the reinforcing bars were bent to sharp angles in the length of the sleeper, occasioned by the reduction in top width for the centre portion. These bars when stressed under load, tend to straighten with the result that the concrete covering is spalled off.

Ordinary reinforced concrete sleepers up to a depth of 7″ and with bars of comparatively considerable diameter, weight and number per sleeper have all cracked in one position or another depending upon the design.

Furthermore, types were made having

the reinforced bars and stirrups welded together so as to form one unit and the concrete mixed and vibrated in the moulds under ideal conditions and strict supervision. All have failed to stand up under fast traffic.

In an endeavour to give some measure of resiliency to the concrete a mix having as part of aggregate, a proportion of sawdust, was used by one manufacturer, but no advantage resulted. The sleeper was lighter in weight by the use of sawdust.

Some sleepers were made of spun concrete, a well known method of improving the quality of the concrete by increasing its density or compactness. This method did improve the strength of the sleeper but the depth, weight and cost figures were so high as to limit the extent of the trial. A recent examination disclosed that some of this type were giving way although the depth of some sleepers was as much as 9″, others were 8½″ and later on some 6½″ were produced.

Prestressed sleepers, first produced in this country in 1942, were laid at Cheddington in 1943. In case prestressed concrete is not understood, the process of pre-stressing may be briefly described with advantage as follows. The reinforcing wires are made of a high grade steel having a high tensile strength of 100 tons per square inch. You will recollect I previously mentioned concrete offers little resistance to tensile stress, and the idea in prestressing is to overcome this weakness.

Knowing the external loads to be imposed on the sleeper, the designer decides how many reinforcing wires are required and their position in the cross section of the sleeper. For instance a sleeper for primary track will require a greater number of wires of the same diameter than one for tertiary track, loading being lighter in the latter case. The wires are stretched between supports, by screw or hydraulic jacks, to a predetermined extent with the moulds in position round the wires. The working stress for the prestressing wires being about 60 % of the ultimate tensile stress. The moulds are then filled with concrete and allowed to set and harden. When the concrete is hard, the stretched wires are released and cut off at the sleeper ends. The released wires tend to shorten and impose a compressive force on the concrete. The concrete is in such a state of permanent compression that the sleeper is capable of carrying the imposed loads without inducing tensile stresses in the concrete it is incapable of resisting. Furthermore, it is possible to get a slight measure of flexibility in the sleeper which is impossible to obtain with the ordinary reinforced concrete sleeper, without cracking of the concrete. The first pre-stressed were made and laid in the Cheddington length on 21-2-43. These were 8′0″ long, 9″ base and had only 16 prestressed wires. About 50 % were cracked in about 3 to 4 months from the time of laying. It was good experience in that most of us thought they would fall to pieces, having such small diameter wires and would crack for the full depth immediately under the rail; 90 % of them are still in the track. The strength of the sleeper was lacking and not of sufficient width and depth, so another batch was put in hand.

In this next trial, three designs were experimented with. Firstly, the width was increased to 10″ and the depth put up to 6½″, all had 20 prestressed wires. (See diagram.) Some of them had a steel plate welded on the ends of the wires at the sleeper ends to provide an anchor. Other had 4 additional wires prestressed to a lesser extent than the 20 wires in the bottom half of the sleeper so that in the event of the bond of the prestressed wires giving way, the 4 wires take up the stresses. The an-

choring and additional wires were found to be unnecessary and also costly, and the 20 wire type stood up to test.

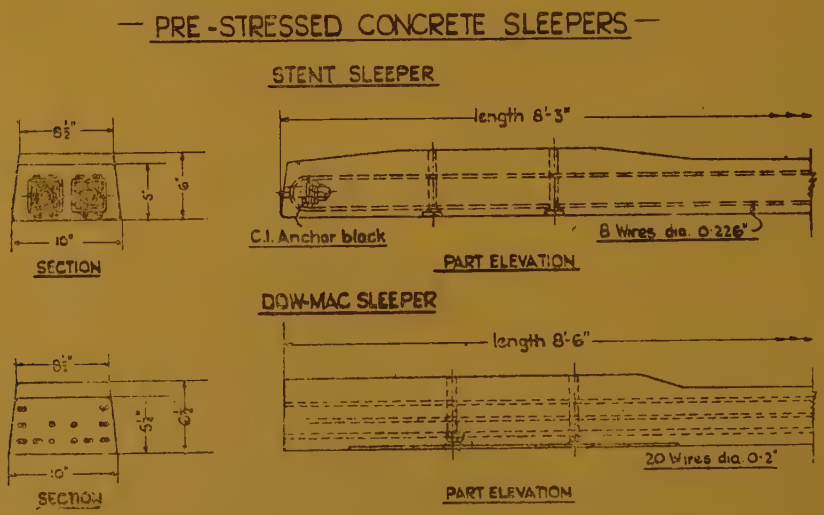
The previous types having been made in temporary moulds, a further batch was manufactured in proper moulds under better conditions. Some of these were put under B.H. rail and some under F.B. rail for comparison purposes. These were laid down in 2-1-44.

In the manufacture of prestressed sleepers, rapid hardening cement is used to expedite curing time. The sleepers are not released from the moulds or the prestressing jacks released until the concrete is sufficiently hard to ensure the bond round the wires, so that about 8 days must elapse before the moulds are released.

It was suggested that quick setting cement (high alumina) should be used to speed up the setting time. Some of the last mentioned design of pre-stressed sleepers were made with this kind of cement and laid in. After a few months, the sleepers commenced to crack, therefore confirming previous experience with this kind of cement that concrete made with it is incapable of standing up to shock loading.

The 20-wire sleeper laid down in 2-1-44 is standing up very well at Cheddington, although a few have recently shown signs of cracking but as speeds of trains have increased over the length, it is not surprising since they are only designed for speeds up to 70 m.p.h.

The next type to be considered worthy of trial was one known as the pre-stressed and anchored type. (See diagram.) You will remember I mentioned some of those laid down in 26-8-45 were anchored by welding a plate on the wires but, owing to cost and its being an unnecessary component, was discarded. In this later type, however, the anchoring device facilitates manufacture as well as providing the anchoring media. With this type of sleeper, the prestressing of the wires is done within each mould, that is to say, each mould is self-contained, whereas with the previous type the prestressing was done over a long length; enough for about



50 sleepers. The reinforcing wires used with this later type are fewer in number, from 8 to 12 as against 20 for the ordinary prestressed type but the diameter is usually greater. This type is less in depth and is lighter than the 20 wire type and is only 8′3″ long as against 8′6″. Some of these prestressed and anchored type were laid in 18-7-46, and are showing quite a number of cracks and spalling off of the concrete along the face in contact with the ballast and at the ends. The type is to be strengthened and further sleepers put to test.

From the point of view of installation and maintenance of concrete sleepers, it is evident that there is greater difficulty and cost as compared with wood sleepers. Firstly, it is not possible to unload concrete sleepers by hand, with the same facility as wood sleepers. In the case of wood sleepers, it is possible to unload them where, shall we say, a period of 30 to 45 minutes between trains can be obtained, and suitable shunting connections exist, but to unload concrete sleepers, due to their greater weight, it is necessary to unload on Sundays, or other week-day periods where longer possessions can be obtained. Furthermore, more men are required to handle the concrete article. In fact, if concrete sleepers in great number are to be handled economically, mechanical appliances must be resorted to. A mobile petrol electric-driven crane has been used for handling concrete sleepers, 3 at a time; a special sling attachment which engages with the chair jaws is a device worthy of recommendation. This crane can be used for loading and unloading; in the latter case the crane travels from waggon to waggon as the sleepers are unloaded; the waggons being fitted with drop-end doors and bridge boards to carry the rubber-tyred wheels over the gap between waggons. Other mechanical devices have been tried such as panting rollers, skids, etc.

Chairing of concrete sleepers has, so far, been done by the platelayers on the lineside, although at the present time this chairing operation is being carried out to a limited extent for the L.M.S. by the sleeper manufacturers. If concrete sleepers are used to considerable extent, it would facilitate unloading on the lineside as well as being economical, if the chairing and bolt tightening were done at a depot; the latter operation by machine.

When laying concrete sleepers, the operation is at the moment more costly in manpower. Whereas, three or four men can conveniently handle the wood sleeper from alongside the track to its position on the ballast bed, at least six men are required to handle similarly the concrete article.

The keying, packing and other work is not very dissimilar when relaying, but with concrete sleepers it is important the sleeper be well packed under the rail so as to avoid end and centre binding. At this juncture it might be well to refer to the special chair designed for use with the concrete sleeper known as the C.S.1. This is less in width than the A.S.I or S.1, as the possibility of indentation of sleeper does not arise, and the contour of the base being oval, there is less tendency to uneven surfaces and point loading. The jaw is designed to suit the steel key, this type of key absorbing any shock loads from flange impact, and the rail seat being cambered lessens any tendency to rocking of the chair on the sleeper.

It is L.M.S. practice to use a felt pad between chair and sleeper and wood and composition pads of various types have been tried out. As this pad is not used for insulation against electrical leakage, I think the felt pad is just sufficient to take up irregularities in surfaces of chair base and sleeper surfaces.

As stated previously, the chair fastening should undoubtedly be of the bolted type, either through bolts or into some

tapped insert or nut cast into the concrete.

I am of the opinion the concrete sleeper requires a little more attention so far as packing is concerned. The non-flexibility (or nearly so) of the concrete sleeper demands the packing should receive more frequent attention, and it is less apparent with the concrete article, that attention is necessary, when compared with the wood article which as it deflects under load, can be seen to require attention.

I consider the maximum size of ballast should be 1½", as if of larger size, uniform packing is unobtainable.

The concrete sleeper consolidates on the ballast quite rapidly, in fact due to its greater stiffness, there is less disturbance of the loose ballast under the rail where load intensity is greatest. Conversely, neglect of packing, due to the greater stiffness increases the moment on it, as a beam, when end or centre binding takes place.

[625 .151 (73)]

Heat-treated switch points show increased service life,

by HORACE C. KNERR,

President, Metlab Company Philadelphia, Pa.

(*Railway Engineering and Maintenance, July 1948.*)

The benefits of correct heat treatment when applied to ordinary open-hearth steel switch points was demonstrated effectively in a recent series of tests conducted under severe service conditions in a busy yard of a large eastern railway. These tests, extending over a period of nearly a year, showed that heat treatment increased the useful life of the switch points 200 to 800 per cent, with consequent savings in labor and material by eliminating the more frequent replacements necessary with ordinary switch points.

For these tests a location was chosen where heavy wear and resulting high maintenance costs were experienced with ordinary switch points. Traffic in this location is heavy — approximately 2 500 movements daily — but speeds are moderate. Switch points identical with ordinary points, but heat treated, were installed at these locations to determine their characteristics as compared with untreated points under the same operating conditions.

General view in test location, showing construction of one of the test switches.

The first test installation was made at a location where conditions were so severe that ordinary switch points wore out in one to six weeks. The

heat-treated switch points at this location gave satisfactory service for 45 weeks, or an increased life of at least 750 per cent. Six other heat-treated points showed no serious signs of wear after service periods of 8 to 12 months where untreated points wore out in 1 to 6 months. At the time of the latest inspection the latter heat-treated points, having already shown an increase in service life of 200 to 800 per cent, were all in excellent condition, with an undetermined period of useful life ahead of them.

Inspection also showed that the heat treatment, intended primarily to improve the wear resistance of the slender, tapered portion of the switch point, also prevented battering or mushrooming of the rail head at the heel of the switch point. This was observed at several locations where the ends of the adjoining untreated rails were badly battered while the heel ends of the switch points showed no signs of wear.

Close-up of one of the heat-treated switch points after 12 months in service, edge still smooth and sharp, apparent roughness is grease.

Heat treatment.

The heat treatment of metals is a highly developed science that has progressed greatly in recent years. When metal is correctly heat treated the internal character of the metal is materially changed, refined and improved, and develops a combination of toughness, reliability, and wear resistance superior to the untreated metal. Heat treatment for best properties involves controlled heating and cooling through the critical temperature of the steel at correctly determined rates, followed by adequate tampering operations — « draw back » — to toughen the metal, impart ductility and shock resistance, and remove internal stresses. Deformation must be kept to the minimum and severe cold straightening must be avoided to prevent internal stresses which may cause the points to bow or twist with age. Steel correctly heat treated is not brittle, and has greater resistance to spalling, mushrooming, or cracking than untreated steel.

In the tests referred to the heat-treated points were initially of open-hearth steel with the following typical composition : carbon 0.80; manganese 0.70; phosphorous 0.010; sulphur 0.030; silicon 0.20. Their Brinell hardness before heat treatment was about 240 to 280. After treatment their Brinell was 350 to 375.

Heat treating was done on the entire points after machining, by a process developed by the Metlab Company, commercial heat treaters and engineers, of Philadelphia, Pa. Quenching was in oil, special means being employed to avoid excessive deformation and minimize subsequent straightening operations. The points were made by the Frog Switch and Manufacturing Company, Carlisle, Pa.

[656 .257 (.44)]

The « electro-mechanical » signal box at Paris-Nord,

by

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Ingénieur principal,
Way & Works Department, Nothern Region,

and

CAUCHOIS,
Ingénieur adjoint
Fixed Equipment Department,

French National Railways.

(*Revue Générale des Chemins de fer, May 1947.*)

The « Revue Générale », in an article in the May-June 1945 issue, by Mr. WALTER, *entitled « The evolution of electric power signal boxes fitted with route levers », gave details of the general line of thought followed by the French National Railways in constructing electric power signal boxes.*

In addition to such boxes, the French National Railways have also put into service a number of mechanical and electro-mechanical type boxes and its designs department has prepared plans for a standard box of each kind. The present article describes the standard electro-mechanical box, the prototype of which was put into service during 1946.

The La Plaine area, just outside the Paris terminus of the Northern Region, was completely devastated in the course of the aerial bombardment of April 21st, 1944 (fig. 1), and of the two mechanical signal boxes controlling entry to the very important La Chapelle marshalling yard one, No. 10 box, controlling the connection to the main running lines, was completely destroyed, while the other, No. 5 box, controlling the entry and outlet from the siding groups and the depot, was so badly damaged that it had to be replaced.

Fig. 1. — Damage done in the area controlled by No. 5 signal box, La Chapelle.

Choice of type of signal box.

Having regard to the new connections which were planned, an electric power signal box was seen to be the correct thing to instal in place of the destroyed No. 10 box. On the other hand, in the case of No. 5 box, and in spite of the enlargement of the area under its control involved in the plans for rebuilding the yard, it was a question whether a mechanical or an electric power box would prove the more suitable.

Seeing that no passenger trains used the main lines, which are even not fitted with the block, controlled by this signal box (La Plaine to Pantin line), there was no need to provide approach and route locking. As, in addition, a number of points are situated close to the signal box, it was less costly to operate them mechanically than elec-

trically. On the other hand, it would have been necessary to have two signalmen always on duty, on account of the size of the locking frame (120 levers, 30 of them spare, to provide for possible extensions).

Finally the signal box being located amidst the areas controlled by the six adjoining boxes, situated a short distance away, made it impossible to instal signals marking the limits of these areas and led to providing slotting control over the absolute stop signals of the adjacent boxes, particularly those worked from No. 12 electric box and No. 14 electro-pneumatic box, where there are colour light signals, not to mention those of the new box No. 10 to be installed in due course. As these controls could only be effected fully by electrical means, there was no reason to provide mechanical transmission in connection with them.

There would have been nothing for it, therefore, but to have had recourse to an electric power box, expensive though that would have been, if the first of the so-called « electro-mechanical » type boxes had not just then become available. This permits of working those points and signals which are near the box mechanically, those which are some distance away and the controls between signal boxes being operated electrically. This type of apparatus, designed and perfected by the Saxby Works, to the requirements of the Designs Section of the Fixed Equipment Department of the French National Railways, completed the series of standard type signal boxes already worked out to meet the various cases arising in service.

Features of modern signal boxes.

For some years past, there has been a certain evolution noticeable in the matter of operating points and signals, due in the first place to the growth of colour light signalling. This means that a certain number of signal indications are brought about automatically (such as the stop and proceed aspect and the caution indication at the approach to an automatic signal), and require no action to be taken by the signalman. Others are controlled from the signal box (absolute stop aspect, reduced speed indications) by means of miniature levers actuating circuit controllers. If the automatic operation of certain signals tends to reduce the number of levers, on the other hand there is a contrary tendency at work also, for the following reasons. There is an advantage in being able to use for the absolute stop signals, whether of the mechanical or the colour light type, a separate lever for each route (or group of routes) to which such signal gives access. This arrangement is intended to enable the signalman to be sure that the route concerned is really the one he intended to set up for the movement. It has also the advantage of simplifying the interlocking between levers.

A further tendency is to have recourse to electric operation for mechanical type signals in a certain number of special cases, such as where a signal is placed at a considerable distance from the signal box (over 1 500 m. = 1 640 yards) or is under the control of several signal boxes under conditions difficult to effect by mechanical means.

For points placed at a certain distance from the box or when several have to be worked by one lever, it is very often best to use electric motor operation.

These considerations led the French National Railways to adopt the following arrangements, taking into account on the one hand the technical conditions governing fitting up and working, and especially that of facilitating the signalman's work, and on the other hand the cost of installation and maintenance.

In the case of very large boxes, controlling complicated layouts with heavy traffic, or when having to meet certain special operating conditions, electric power boxes are absolutely essential.

For the ordinary run of signal boxes of comparatively small importance, the 1945 mechanical type is being adopted. This has individual levers, mechanically interlocked by grids and sliding locking bars (*).

Operation is effected by means of full size levers of the « half-revolution » type, the catch handle acting on the mechanical or electrical locking apparatus as well as on the circuit controllers. In the case of electric operation of a function, the full size lever is replaced by a miniature one, acting directly on those parts. The mechanical type 1945 signal frame is simple, strong, economic to use, and lends itself readily to any subsequent alterations in an installation. However, its use has been limited to a maximum of 60 levers, for constructional and space reasons. A larger frame of this type would in fact necessitate a signal box of large dimensions and it is not always possible to build one close to the area which it has to control. The locking box would have to have grids containing a larger number of openings and sliding bars, rendering its accessibility for inspection and maintenance more difficult. The great length of the group of levers would increase the amount of walking about to be done by the signalman. In addition, experience shows that under present day conditions of working such equipment, 60 mechanical transmissions in a lead-out represent the practicable maximum. Any supplementary levers would therefore have to be tiny ones for electric operation, the fitting of which does not require them to be placed at such wide centres as the full size levers used for mechanical transmissions, but the size and form of the grids used in the locking box of the 1945 type frame do not allow of the centres being reduced. This disadvantage could however be diminished by using miniature 3-position levers. This would reduce the length of the apparatus, but the locking box would have to have grids mounted one above the other, an arrangement which gives rise to considerable maintenance difficulties.

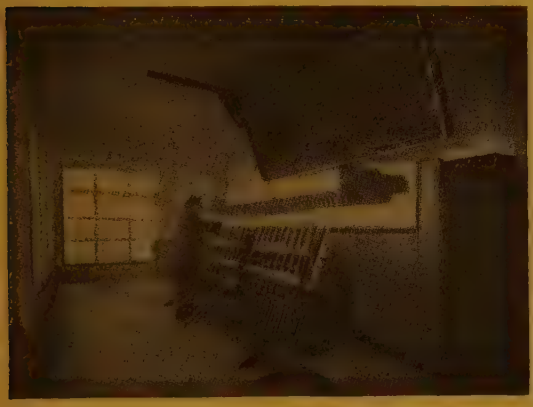

Fig. 2. — Interior of electro-mechanical signal box.

These considerations led to a new type of signal box (figs. 2 and 3) being worked out, less onerous than the individual electric type, and retaining mechanical operation for functions situated close to it. This became known as the « standard electro-mechanical signal box ». The levers are arranged in two rows, one above the other, the lower being simply a 1945 type mechanical frame and intended to operate all the purely mechanical functions. The upper row consists of miniature 2-position levers of a special type, controlling the electrically worked functions, the centres of these being half that of the

(*) *Note by the translator.* — This type of locking, using the original Saxby « grids » has not been used in new work in Great Britain for many years past.

full-size levers. This results in an electro-mechanical frame containing three times as many levers as a mechanical one of the same length. Thus a frame of 180 levers would correspond in length to a 60 lever S.N.C.F. 1945 type mechanical frame, the maximum size allowed for that type. In practice the following sizes of electro-mechanical frames have been arranged for, viz.:—

90 — 120 — 150 and 180 levers.

As the electro-mechanical signal boxes usually control a fairly extensive area, the proportion of two electric levers to each mechanical one appears to correspond pretty closely to service conditions. If the proportion should need to be a little different from this, it is always possible to arrange for each row of levers to contain the number required, the length of the signal box being then determined by that of the greater row. If need be the number of electric levers can be increased by replacing some full-size levers in the

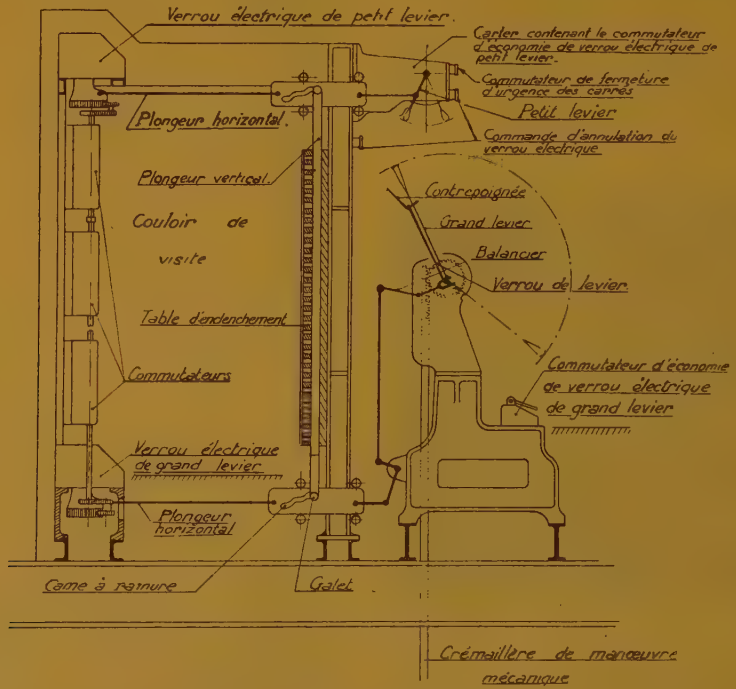

Fig. 3. — Diagrammatic cross-section of electro-mechanical frame.

Explanation of French terms.

Verrou électrique de petit levier = electric lock on miniature lever. — Carter contenant le commutateur d'économie de verrou électrique de petit levier = case containing economiser contact for miniature lever electric lock. — Commutateur de fermeture d'urgence des carrés = switch for throwing stop signals to danger in an emergency. — Petit levier = miniature lever. — Commande d'annulation du verrou électrique = optional emergency release device for electric lock. — Contrepoignée = catch handle. — Grand levier = full size lever. — Balancier = crossbar. — Verrou de levier = catch block. — Commutateur d'économie de verrou électrique de grand levier = economiser contact for full size lever electric lock. — Galet = roller. — Came à rainure = slotted cam. — Verrou électrique de grand levier = electric lock on full size lever. — Commutateurs = circuit controllers. — Table d'enclenchement = locking box. — Couloir de visite = inspection gangway. — Crémaillère de manœuvre mécanique = rack for operating mechanical transmission. — Plongeur horizontal = horizontal connecting rod. — Plongeur vertical = locking tappet.

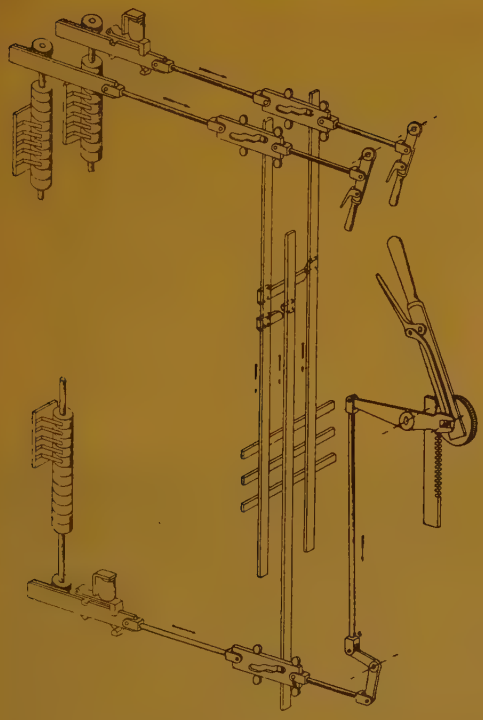

Fig. 4. — Perspective sketch of the frame.

lower row by miniature ones of the type used in the 1945 class mechanical frames.

The operation and lead-out of the rod and wire transmissions are the same as in the 1945 type frames. On the other hand, it was not possible to retain the usual grids and slide bars for effecting the interlocking between levers by reason of the great amount of space required, it being preferable to use the « Stevens » or tappet type locking box. Each lever, mechanical or electrical, actuates a vertical tappet and the interlocking is effected by the displacement of horizontal locking bars.

Description of the electro-mechanical signal box.

The practical realisation of the programme outlined above led to the construction of a rigidly mounted assembly (figs. 2, 3, 4 and 5) containing the levers, locking box, electric locks, circuits controllers, and a certain number of subsidiary devices.

The locking box has been arranged vertically behind the levers with an inspection gangway between it and the electrical equipment, which is therefore accessible both from the front and the back.

Over the whole assembly is mounted an indicating diagram (fig. 6) on which are grouped, in accordance with the actual arrangement of the layout, all the indications referring to the track, proving and detecting circuits.

Levers. — The full-size levers are of the same pattern as those used in the 1945 type mechanical frame, and are of the half-revolution pattern, acting by a pinion on a

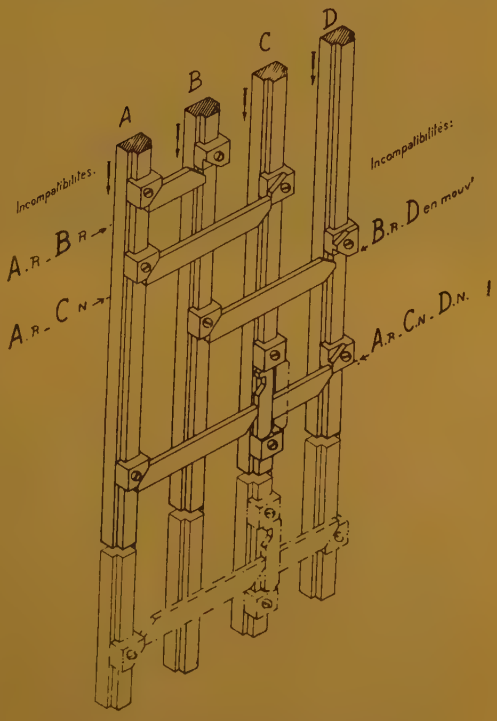

Fig. 5. — Locking dogs and tappets.

rack, the latter being coupled directly to the transmission in the case of rod working. In the case of a wire transmission, the rack actuates a cross bar to which can be attached the outgoing wires, at different points according to the amount of stroke required.

The lever has a catch handle acting on a catchblock which secures the lever in either extreme position, normal or reversed. It also acts on a cross bar connected by rods and cranks to a cam provided with a slot which in turn actuates the vertical tappet in the locking box and when the case requires it a circuit controller. This mechanism is capable of being locked by an electric lock. Thus both the mechanical and the electrical locking act finally on the catch-handle.

Locking box — This is about 2 m. (6′6¾″) high and made up of interchangeable standard parts of cast iron, with vertical channels for the tappets and horizontal channels for the locking bars.

The vertical tappets, placed at 42.3 mm.. ($1^{11}/_{16}$″) centres, have a stroke of 12 mm. ($^{15}/_{32}$″) and are actuated by a cam in the slot of which runs a roller attached to the tappet. This arrangement renders the stroke independent of any play liable to be produced in the operating mechanism by wear in the various pins and joints.

The locking dogs are attached to the tappets by screws. By using movable pieces on certain of the tappets, conditional locking combinations are obtained (fig. 5).

Fig. 6. — Illuminated diagram.

The miniature levers perform the same function as the catch handle of the full-size ones, and are of two types :

a) those in the upper row, acting directly on the rod and crank connections just mentioned ;

b) those in the lower row, which are of the type designed for use with the 1945 mechanical frame, mounted on special bases and taking the place of full-size levers. These act on the road and crank connections through a cross-bar.

Both types have a catch-handle provided only to hold them normal or reversed, and in the case of the first mentioned type this also actuates an economiser contact in the electric lock circuit.

Electric lever circuit controller. — This is made of 20 contact elements mounted along a vertical shaft capable of rotating through 120° under the action of the lever, transmitted through a rack driven by a connecting rod attached to the slotted cam.

Teeth allow of each of these elements being adjusted in stages of 5° of angle with respect to the shaft.

Electric lock. — This allows of the lever being locked both normal and reversed or in one only of these positions, either directly (miniature lever) or through the catch-handle in its dropped position (full size lever). It acts upon the horizontal connecting rod attached to the slotted cam.

The lock has normal proving contact springs and a forced drop attachment to

prevent the armature remaining incorrectly against the electro-magnet from any accidental cause, and so leaving the lever free when it should be locked.

By actuating a pull-rod placed in a small case projecting from the number plate of the lever concerned, the lock can be released, through a flexible wire connection. This cancelling of the locking action, which is neutralized when the lever is moved, must be repeated on each occasion of having to reverse either a full-size or miniature lever in these circumstances.

Economiser contacts in electric lock circuits. — These avoid having to keep the electric lock coils continuously energised.

In the case of the full-size levers the contact is a foot contact placed at floor level alongside the lever concerned. This is of the Saxby type in general use in mechanical signal boxes.

The contact used with the miniature lever is fixed on the same base casting as the lever and is actuated by the catch-handle.

Switch for throwing signal to danger in an emergency. — This only differs from the economiser contact used with the miniature lever by the arrangement and number of the contacts themselves, but it is made up of the same elements. These switches are placed just above the cancelling mechanisms, with repeat resetting action, applied to the electric locks and are operated from outside by press-buttons or pull rods.

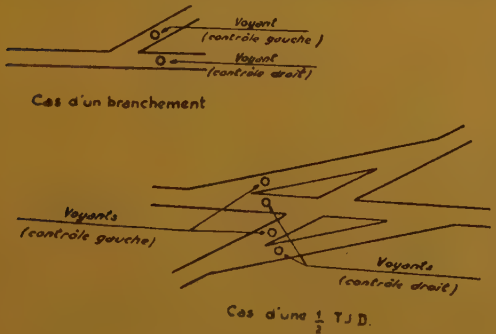

Fig. 7. — Indicators showing position of points.

Explanation of French terms.

Voyant = indication. — Contrôle gauche = detection for left-hand route. — Contrôle droit = detection for right-hand route. — Cas d'un branchement = turnout. — Cas d'une ½ TJD = one end of set of double slip points.

The same arrangement allows of an absolute stop signal being changed into a stop and proceed signal, or of the stick control of a signal being cut out of action, should circumstances so require.

Illuminated diagram.

The visual indication of the permanent point detection controls where provided, as well as the proving signals at danger, slotting between signal boxes, and occupation of track circuits, have been grouped together on an illuminated track diagram, normally lighted (fig. 6), but less complete in character than the type used in the electric power signal boxes, as it does not give a continuous indication of a route that has been set up. Fixed above the locking box it is supported by a guide attached to the ceiling, which allows of it being moved and set to any particular slope quite easily.

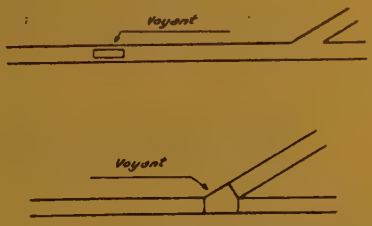

Fig. 8. — Track circuit occupation indicators.

(Wording as for fig. 7.)

It has a black background on which are shown in white those lines which are not track circuited and in blue, yellow, green or red those which are.

The indications appear in small translucent openings in the diagram.

Indication of the position of points.

a) *Points equipped with constant detection.* — On each of the tracks which diverge at the points there is a small white lamp which burns if the tongues are correctly in the position corresponding to that of the controlling lever (fig. 7).

b) *Points not equipped with constant detection.* — These are marked with the letter *s* on the diagram and if they are not closed the fact is merely indicated by the ringing of a bell common to all the points taken facing in the down, or of another common to all those taken facing in the up, direction.

Indication of occupancy of track circuits.

This is given by the lighting up, in white if the track is clear or red if it is occupied, of an opening situated (fig. 8) in the middle of the length of track circuit if this does not protect or lock any points, or at the points themselves if its does protect or lock them.

Other indications.

The other indications are provided by means of small round openings, placed in the middle of signs or marks indicative of the nature of the function which is being proved, detected or repeated, such as a signal, disengager, etc., and placed outside and to the left of the representation of the line concerned, considered in the sense of the direction of traffic using such line.

Power supply.

The signal box in question being located in an area intended to be electrified, all circuits, other than those of the electric lever locks on the frame and the detection warning bells, are fed from a permanent single-phase AC supply.

The voltage is 115 for the signalling and 24 for the lamps on the illuminated diagram.

The electric bell circuits are fed at 8 V. and those of the electric locks at 24 V. DC from a set of accumulators, trickle charged by a transformer-rectifier set branched off the permanent 155 V. AC supply at the signal box. An intermediate tapping on this battery provides the 8 V. feed for the bells.

The permanent AC supply is provided by the existing sub-stations at St. Denis, from which it is fed to the signal box at 440 V. and there transformed down to 115 V. or 24 V.

Fig. 9. — Signal box building.

The signal box building (fig. 9).

The frame is installed in a signal box built to the standard type designed by the Fixed Equipment Department. It is glazed on three faces and affords perfect visibility over the whole of the area controlled from it.

The floor level in the operating room is lower towards the back and inside the locking frame assembly to allow of easy access to the mechanical and electrical equipment.

On the first floor there is a small kitchen for the signalman's use, and on the ground floor there are the mechanical lead-out room, a relay room, a power supply chamber,

Fig. 10. — Installing the frame.
Front view.

storeroom, bicycle room, W.C., coal bin, and central heating boiler. The whole forms a compact and simple assembly of agreeable appearance.

The work of installing.

The work of installing the prototype apparatus constructed at the Saxby Works at Creil was carried out by the makers without any technical difficulty being met with, even in connection with the rather delicate operation of adjusting the locking bars and fitting them in place on the frame.

Figs. 10 and 11 show the signal box at various stages of completion.

Putting in service.

The signal box was put into service under excellent conditions and has given complete satisfaction since that time.

Fig. 2 shows the completed assembly, which takes up a very reduced space for a 120 lever frame. The body of it is entirely closed in and presents a very satisfactory appearance. Its neat lines harmonise completely with those of the signal box itself.

This type of frame, which compared with certain earlier installations, presents some original features in connection with the lever locks and their optional release equipment, as well as in the interesting details of the illuminated diagram, and of the various push buttons associated with stick control, substitution of the stop and proceed for the absolute stop aspect and emergency replacement of a signal to danger, has enabled the problem met with at La Chapelle to be solved completely.

It is well adapted to find an extended application in those cases where a certain proportion of the functions operated from the signal box can be worked mechanically.

It offers the advantage of an attractive first cost price, especially by reason of the relatively small size of the building required.

The « electro-mechanical » signal box, by filling the gap which existed between the mechanical type box, kept for use in small installations, and the various modern electric power boxes, thus completes in the happiest manner the series of standard designs of signal box worked out of recent years along unified lines by the engineers of the French National Railways.

Fig. 11. — Installing the frame.
Rear view.

NEW BOOKS AND PUBLICATIONS.

[**624** (03, **69** (03 & **72** (03]

BODSON (Fernand), Architect. — **Dictionnaire des termes récents symboles et abréviations.** — Achitecture, Art de construire, Génie civil. — *(Dictionary of recent expressions, symbols and abbreviations. — Architecture, Building and Civil Engineering.)* — One volume bound in cloth (5½ × 7 inches) of 256 pages. — 1948, Brussels EDITEC, rue Paul Spaak, 2. (Price : 300 Belgian francs.)

The first volume of M. Fernand Bodson's « *Dictionary of recent expressions, symbols and abbreviations in Architecture and Civil Engineering* » is undoubtedly very illuminating and detailed, and will be extremely useful to all architects and civil engineers and technicians.

With the assistance of scientists, who have brought their specialised knowledge to bear on the many fields covered, the author has collected together some 2 500 expressions, 750 of which are given in this first volume.

The firm of EDITEC has made an excellent job of publishing this work. The various special technical dictionaries relating to civil engineering, building and architecture are far from being complete. In many cases, they deal very thoroughly with one or other branch of the subject and owing to their very nature leave serious gaps from the point of view of the terms and expressions in current use in building. They are in fact only fragmentary. As for general dictionaries, these do not always include the words for which one is seeking, or else do not give sufficiently detailed information.

Moreover, changes in building practice are constantly occurring, and with them a host of new words.

As one reviewer of M. Bodson's book asks, what exactly are D.I.N., B.T.U., S.T.D.S., thixotropie, pound av., rock wool, or workability ?

An up-to-date book was required to enlighten our ignorance.

This first volume makes us think that here we have exactly what is wanted; the book is like an abbreviated course in building theory and practice, as the reader can see by the definition of the term « fluage » (page 84) which we have taken at random from the 750 dealt with in the book.

In his preface the author expresses himself thus :

« Our readers will find in these pages:

» The latest data and decisions of congresses and international agreements, of laws and decrees concerning units of measure and their symbols. For example : B.T.U. — mm. — Sabine — pieze — Ply — Stds — etc...

» The explanation of recent terms and neologisms used by specialists in the various branches of civil engineering. For ex. : lignostone — fer armco — nephelometre — thixetropie — etc...

» Definitions given by skilled architects of architectural terms. For ex. : aera — cour anglaise — bungalow — gaine — duplex — etc...

» The latest and most accurate information on the metrical equivalents of English and American weights and measures. For ex. : pound av. — bbl — sq. yd. — oz. — etc...

» Translations and definitions of foreign terms; for ex. : silt — sleck-spate — iroko — rock wool — shunter — workability — etc...

» The explanation of initials which are used inordinately and render the meaning most obscure to the uninitiated. For example : F.A.B.I. — O.T.U.A. — C.H.R. — D.I.L. — E.N.S. — I.B.N. — etc... »

To conclude, in our opinion this dictionary wehrein everything is done to facilitate looking up a word, a measure, or a symbol will meet with well deserved popularity in the building trade.

J. D.

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621 .13 (02 |

DEVERNAY (E.), former pupil of the Polytechnique School, Engineer to the French National Railways, with a preface by M. A. PARMANTIER, Head of the Technical Services of the Rolling Stock and Traction Department of the French National Railways. — **La locomotive actuelle.** *(The present day locomotive.) Third edition.* — One volume (6 × 9 1/2 inches) of 536 pages with 489 figures. — 1948, Paris (VI^e^), Dunod, éditeur, 92, rue Bonaparte. (Price : 950 French francs.)

For several lustra the steam locomotive has seen the competition of electric traction increase and strengthen, to mention one form of competition only. Already after the first world war extensive schemes were put forward together with plans for the use of hydraulic resources. It is only necessary to read the reported discussions of the Rome Railway Congress (1922) to see how this technique had already advanced at that date. The progress since made and various circumstances to which the second world war gave birth have given a new impetus to what can no longer be described as a new method of traction.

Though she may have to give way to her rival on the main lines, the steam locomotive continues to play a very important role. The engineers who have to keep the services at the expected level of perfection have unceasingly improved it. The power, speed, output, and safety of running have all increased to a degree never dreamt of in earlier days. In the repair shops and in the traction offices very careful organisation has led to a considerable increase in the average mileage.

M. Devernay's book is an eloquent testimony to the efforts made to improve the steam locomotive and a meticulous inventory of all the results obtained. Side by side with the classic arrangements and a report of the theories which form the basis of the utilisation of the heat supplied by the fuel, he gives for the three essential parts, the boiler, the frame, and the engine, an analysis of the most fruitful inventions inspired either by theoretical research or by the new resources of metallurgy or mechanical construction.

The author has not confined himself entirely to the locomotive. He also gives a description of the most up-to-date braking equipment, safety equipment whose interest has increased as the speeds have increased and now that the continuous brake is used on goods trains. In this same field of safety equipment he also describes cab signalling equipment. A controversial question for some twenty years, this has now been solved in various ways on all the main line railways.

In an appendix M. Devernay gives the characteristics and performances of the most noteworthy of the latest locomotives in a great many countries. This table makes it possible to judge the

remarkable results that can be achieved by patient study and conscientious trials.

This third edition enriched by the latest technical developments will certainly meet with the same favourable reception as the two previous ones. It will prove valuable to all those who have to study new types of locomotives or improve existing types, as well as all those who have to use steam locomotives.

E. M.

[621 .13 (02]

SAUVAGE (Edouard), Ingénieur en Chef Honoraire des Chemins de fer d'Etat français, Lauréat de l'Institut, and CHAPELON (André), Ingénieur des Arts et Manufactures, Chef des études de Locomotives à la S. N. C. F., Maître de Conférences à l'Ecole Centrale, Lauréat de l'Institut. — **La Machine Locomotive.** Manuel pratique donnant la description des organes et du fonctionnement de la locomotive à l'usage des mécaniciens et chauffeurs. (**The Locomotive.** *A practical handbook describing the component parts and working of the locomotive for the use of drivers and firemen.) (10th edition).* — One volume ($5^1/_8 \times 8$ inches) of 668 pages with 521 figures. — 1948, Paris and Liége, Librairie Polytechnique Ch. Béranger. — Paris, 15, rue des Saints-Pères; Liége, 1, quai W. Churchill. (Price : 950 French francs; not including postage.)

M. Edouard SAUVAGE's book has long been the vade-mecum of the locomotive staff of the French Railways. The first edition which appeared as long ago as 1894 was originally distributed to the employees of the Est Company. It was soon in circulation all over the country and the success it met with is proved by the many editions which have since been published.

Its lasting popularity proves that the author was able to satisfy the legitimate curiosity of those interested in the subject. His aim was to make them better acquainted with the principles and details of the machine in their charge.

In his descriptions and explanations he has endeavoured above all to be very clear without minimising the complications of certain parts of a study of engines.

Moreover he has profited in each new edition by the chance of making those improvements suggested by experience and including the latest scientific discoveries.

M. Edouard SAUVAGE died whilst preparing the *tenth edition* of the book. The task has been completed by M. André CHAPELON whose recent work has had such a happy result on the efficiency of steam locomotives and thus this book is enriched by extremely interesting information in connection with this branch of mechanics.

In many countries, and in France in particular, the electrification of the railway has recently been considerably extended owing to the new possibilities discovered in electricity together with various circumstances due to the war. The internal combustion engine is yet another rival. It can however be affirmed that the steam locomotive is far from becoming obsolete, and its services will still be required for a long time to come. The unceasing improvements which have made it possible to increase its power, speed and efficiency are undeniable symptoms of its vitality. Therefore this book, produced by two qualified authors, consisting as it does of

abundant matter prepared by the efforts of the most competent French railwaymen, is of untold value and usefulness.

The whole locomotive is disected and analysed minutely. All the various parts are described in detail, together with the materials used, the reason for the arrangements adopted, and their effect on the working, efficiency and safety of running.

Although the book is intended above all for locomotive staff, all engineers are certain to find it full of valuable information for their guidance both in carrying out their daily task and in their research work.

E. M.

[38 (.494)]

BAUMGARTNER (Jean-Pierre), Doctor of Political Science. — **Le trafic des moyens de transport et la conjoncture économique en Suisse de 1901 à 1944.** (The traffic of the methods of transport and economic circumstances in Switzerland from 1901 to 1944). — One volume ($6^1/_4 \times 9$ inches) of 124 pages, with 9 figures and numerous tables. — 1947, Berne, Editions Staempfli & C^ie. (Price : 7.30 Swiss francs.)

The author set himself the task of studying the relationship between economic activity and the traffic of the different methods of transport (railway, road and water transport, air transport, postal services and telegraph and wireless communications). From his investigations he has endeavoured to decide whether the managements could by examining the variations in the economic indices make the necessary provisions to adapt their working to traffic demands. In addition he wished to see whether it would be possible to correct to some extent the harmful effects of variations in the traffic by means of a rating policy.

His first task was to discuss the value of such criteria as can characterise the evolution of the national economy and to extract from known statistical elements the figures representing their variations over the period in question. The author then explains the method he proposes to use to determine if and to what extent the traffic carried by the various methods of transport undergoes variations which do or do not agree with those of this economy.

Applying this method to the different undertakings he finds that transport is influenced in different ways by economic slumps or booms.

In the case of the railway in particular which is studied at the greatest length, an examination of the statistics leads him to make some very interesting remarks which we have not space to mention here. This gives rise to a very profound discussion into the causes of divergencies or agreements which often appear paradoxical. It may be mentioned that the total gross railway traffic corresponds more or less to the economic cycle, the total goods traffic expressed in tonnes-kilometres corresponding positively to the economic cycle whereas the passenger traffic is less sensitive thereto.

Special mention is made of the ratio between the goods and passenger traffic. Since 1914 this ratio has corresponded positively to the economic cycle. Usually a falling off in traffic precedes an economic depression by one year.

Regarding the possibility of arbitrarily influencing the economic cycle by a modification of the rates, the author for

various reasons is dubious but does not altogether dismiss the possibility of using this method in comjunction with a whole series of monetary, financial and fiscal measures.

In the case of other kinds of transport, the passenger traffic on the tramways only occasionally and very approximately corresponds to the economic cycle, while their goods traffic only agrees with it very irregularly and approximately. On the funicular railways the passenger traffic corresponds very positively with the economic cycle, whereas the goods traffic up to the present only corresponds very approximately.

In the case of road transport the author regrets the absence of sufficient statistics relative to passenger traffic and mentions in this connection that in the United States of America a serious effort has been made in this field with results which make it possible to work out useful comparisons. In his opinion American statistical methods should also be used in Switzerland. In the case of goods traffic, in the United States again, by means of the elementary information supplied by the majority of transport undertakings to the Interstate Commerce Commission it has been possible to follow continuously the evolution of this kind of transport. It would be very desirable to introduce a system of statistical data in European countries on the activity of the motorcar and motor lorry. This is an indispensable condition for a rational transport policy. On the basis of the few facts known, the author finds that the number of cars on the roads varies generally in agreement with the economic cycle, and corresponds exactly with it in 1936, the year of the great slump. The effect of the lorries in service varies in accordance with the state of the economic cycle and only corresponded positively with it in 1936.

In his concluding chapter the author makes some further very interesting remarks based on his researches. In a general way in the case of most methods of transport, the variations in the traffic correspond more or less regularly with the economic situation. Only the total annual goods traffic of the railway corresponds positively with it, however, without exception and with no appreciable time lag. This is a point which the author considers to be one of the surest criteria of the economic situation, if not the surest.

As regards the question of knowing if it is possible to forecast the evolution of the traffic over a definite future period, the reply given is in the negative. We will leave it to the reader to find out the arguments on which this opinion is based. Even the ratio between the goods traffic and the passenger traffic, the variations in which very often precede by one year those of the economic cycle, does not make it possible to foresee the exact moment of the crisis or the recovery, and in addition it gives no information on the quantitative evolution of the goods traffic.

As an appendix, under the heading bibliography, the author gives us a very valuable collection of original passages from the most important sources from which he studied the problem covered by this book.

E. M.

[621 .31 (.73)]

Association of American Railroads (A. A. R.), Signal section. — **American Railway signaling - Principles and Practice.** — *Chapter IX.* **Rectifiers and battery chargers.** — One brochure (6 × 9 inches) of 46 pages, illustrated. — Published by the Signal Section of the Association of American Railroads, 30, Vesey Street, New York, N. Y.

Rectifiers are extensively used on the American railways. Many installations, especially light signals, work on direct current whereas the supply is alternating current. Moreover, as a safeguard against current failures, it is necessary to have sets of accumulators available of carefully selected capacity, and these can only be charged by direct current.

Sometimes also the battery consists of primary elements. The rectifier then has to supply all the current needed for the equipment with the exception of several milliamperes which the battery must supply in order to remain in working order.

Various types of rectifiers are used : motor-generator groups, mercury arc, gas tube, the mechanical or vibrator type, the electrolytic valve with tantal electrode, and finally dry elements using copper oxide or selenium.

The elementary theory of each of these systems as well as the working thereof is explained in this volume. Diagrams showing the wiring make it easy to follow the flow of the current. Photographs show what the apparatus look like from the outside.

In several cases a historical note throws light upon the evolution of science in this special field. It will be noted that the first experimental installations making use of the electrolytic valve were tried out in railway signalling.

Brief and accurate instructions are given concerning the essential precautions to be taken in fitting up and to assure perfect maintenance and correct servicing of the apparatus.

A complete diagram for an automatic block makes it easy to see how part of the track circuit is fed from the primary high tension supply, and the other part of the signal circuits by means of rectifiers and batteries working in parallel.

The rectifiers meet the permanent demand for current and at the same time keep the batteries charged. The latter are used to supply any accidental need for more current. This is known as the alternating current floating storage battery system. The author justifies the name by explaining the analogy with a water tower which is kept permanently supplied by a pump whose output is adapted to the average demand though it is able to supply larger quantities of water at certain times.

This Chapter IX is a document of equal value from all points of view to the other publications of the Association of American Railroads, Signal Section, which have already been reviewed in the *Bulletin.*

E. M.

[621 .3 (06 (.492)]

Second Congress on Electro-Thermics and Electro-Chemistry.

(The Hague, 3-4 September 1 47.)

The « Netherlands Institute for Electro-Thermics and Electro-Chemistry » has sent us the two papers presented to it on the occasion of its second Congress held at the Hague in September 1947.

These documents derive their interest not only from the subjects treated but also from the high qualifications of their authors, who are particularly well-informed specialists and experts in their subject.

Following the method adopted a long time ago by our International Railway Congress Association, the advantages of which are obvious, the papers relating to one group of subjects are summarised and presented in abridged form in a special paper. Thus the 29 original papers are followed by 6 special ones.

From the nature of the case, there has been a certain amount of overlapping between some of the groups, but this does not interfere adversely with the classification set up by the organisers of the Congress nor the subjects included in each group as indicated by the special reporters thereon and reproduced in the following list :—

List of groups with subject covered by each :

Group A :

Development of electric heating for industrial purposes 4 papers.

Group B :

Low temperature heating . . 7 »

Group C :

Resistance type furnaces for industrial purposes . . . 10 »

Group D :

Induction and di-electric methods of heating . . . . 5 papers.

Group E :

Measurement and regulation of temperature . . . . . 2 »

Group F :

The electroliser . . . . . 1 »

As will be seen, although not covering a defined number and class of applications of electricity, the field investigated by the reporters is very extensive. We can only give here a few short indications of the scope of their papers.

In group A, the authors have analysed the development of electric heating during the period 1939 to 1946, a much disturbed time, and in two countries, Holland and Switzerland, where the circumstances were very different in many respects.

Electric space heating gives rise to a report of very up-to-date ideas and ingenious realisations in the two reports belonging to group B. The others deal with the results obtained and the possibilities hoped for in baking, cheese-making, grass drying and horticulture.

The special reporter of group C has analysed the reports submitted to him by classifying them in the following order :

General.

Special applications :
radiation furnaces;

siderurgy;

rotatory furnaces for ferro-alloys;

high temperature kilns used for ceramics.

Investigation into the life of materials of high resistivity.

This brief enunciation will suffice to show the extensive field covered by this group. The discussions on industrial furnaces producing ferrous and non-ferrous metals will enable the specialists to form an opinion on their respective qualities and the manufacturing results. Moreover the remarks made and the questions raised by the special reporter during his critical examination stress the value of the information collected, and undoubtedly led to a very valuable exchange of opinions.

Metallurgy is again the main item in the investigations of group D. We see the fields opened up by the use of induction heating in heavy industry, the possibilities of di-electric heating and of high frequency heating, increased by the recent introduction of a new type of generator, the generator with electronic valves. In the research work and applications carried out by French industry in connection with induction heating, it is obvious that the rubber and glass industries have also profited.

There are two papers by Swiss authors, which introduce the reader to the field of measuring and regulating temperature. The object to be attained is economic in character, but control over the temperature may also be necessitated by the nature of an installation. Without giving the ideas set forth in the papers, it is not possible to understand clearly the action of the regulating devices made use of. They operate some under the influence of temperature, the others, — very interesting appliances — under the action of other physical properties, such as pressure or the level of water in electrically fired boilers. Here again the remarks made by the special reporter seem to indicate that in this still recent field of technical development the way remains open to new steps in advance.

In the sole paper presented under group F, the author describes the development and construction of the present bi-polar electroliser made by the Oerlikon firm. Taking the different stages of development of the bi-polar electrolisers, he explains the difficulties met with and the manner in which they have been overcome. The special reporter in turn indicates what are the characteristics of other types of electrolisers, selected from among the most well-known.

The information in the documents which we have touched on lightly above may appear somewhat outside the main activities of readers of this *Bulletin*. It is sufficient to point out, however, that the railways are very large consumers of various materials and metallurgical products, both ordinary and special, and dependent upon a number of industries for them. Always desirous of improving their methods of operation they view with satisfaction the efforts made to improve the manufacture and the qualities of the materials, which they may be able to make use of to their benefit. If we consider too the high level of scientific attainment and technical ability represented in the labours of the Second Congress on Electro-Thermics and Electro-Chemistry, it may fairly be said that it has a double title to be mentioned here.

E. M.